Master-Fit

A.O. Smith Commercial Water Heaters

Service Handbook

BTR, BTRC Models 120 Through 500
Series 100 - 109

Note: This Service Information Also Applies To BTC Models 120-500

Prepared By The Training Department in Ashland City, Tennessee

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TC-043R3

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BTR HANDBOOK
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BTR WORKBOOK INTRODUCTION

This service handbook is designed to aid in servicing and troubleshooting A.O. Smith BTR water heaters in the field. No duplication or reproduction of this book may be made without the express written authorization of the A.O. Smith Water Products Company.

The following text and illustrations will provide you with a step by step procedure to verify proper installation, operation, and troubleshooting procedures. Additional quick reference data is included to assist you in servicing this product.

The information contained in this handbook is designed to answer common questions encountered in the operation of the BTR product line and is not meant to be all inclusive. If you are experiencing a problem not covered in this handbook, please contact the A.O. Smith Technical Information Department at 1-800-527-1953 or your local A.O. Smith Water Products Company representative for further assistance. This handbook is intended for use by licensed plumbing professionals and reference should be made to the installation manual accompanying the product. This handbook contains supplemental information to the BTR installation and operation manual.

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Qualifications: Installation or service of this water heater requires ability equivalent to that of a licensed tradesman in the field involved. Plumbing, air supply, venting, gas supply and electrical testing skills are required.

Tools Required:

- Phillips head screwdriver
- standard screwdrivers
- a 3/8 and 7/16 inch open end wrench
- set of marked drill bits
- an electrical multimeter tester capable of measuring continuity
- gas pressure gauge or manometer (gauge - AOS pt. no. 8099-2)
- water pressure gauge (AOS pt. no. 4798)
- thermometer (AOS pt no. 4870 - range 0 - 220 degree F)
- 1/2 inch socket with extension for removal of the clean out cover,
- 1 1/16 inch socket with extension for anode removal.

MISC: TC-043 Revision 1 vs. TC-043

Revision 1:

- Adds Additional model's information.
- Adds cover statement this Handbook's also a Service Handbook for many BTC Models.
- Includes Power vent kit information.
- Includes BTR/C-500 gas valve information.
- Updated Damper illustrations.

Revision2:

- Revised Part Numbers on Page 15

Revision 3:

- Adds information unique to the Efflkal damper equipped (Series 110, 111 and Retrofit) models

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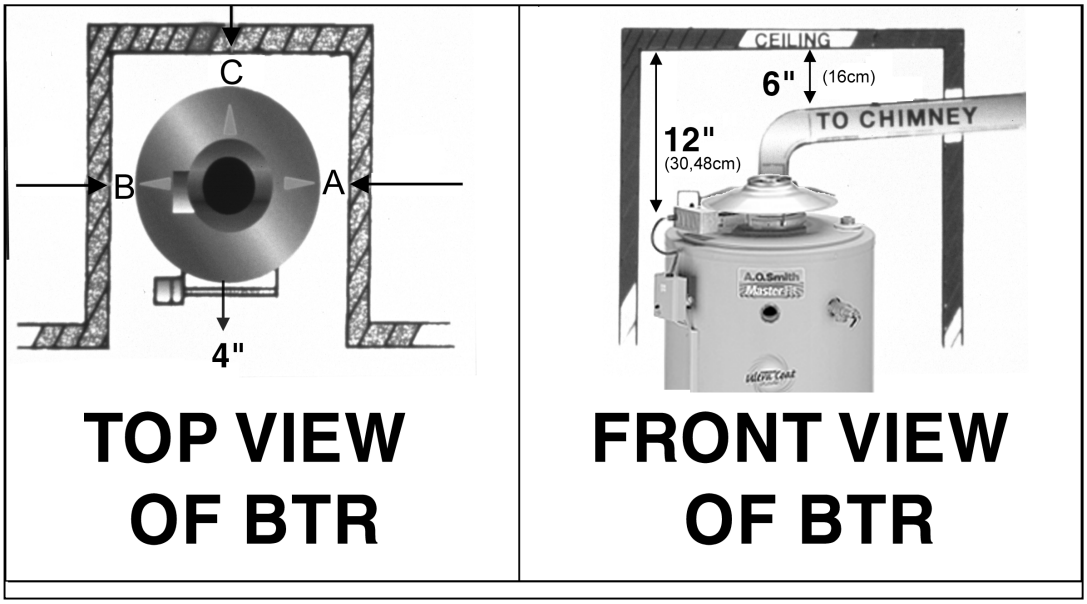
INSTALLATION

This portion of the handbook will review some often overlooked installation considerations, taking note of necessary installation requirements for the BTR 120 through 500 model heaters. The installation manual covers most of these items in detail.

CLEARANCES FROM COMBUSTIBLES



Clearance to Combustibles Table

MODEL	A	B	C
120 - 200	1” (2.54CM)	1” (2.54CM)	1” (2.54CM)
250 - 305	2” (5.08CM)	2” (5.08CM)	2” (5.08CM)
365 - 500	3” (7.75CM)	3” (7.75CM)	3” (7.75CM)

A 24 inch clearance for all serviceable parts is recommended. Clearances may vary between BTR models – See instruction manual or the label on the heater, for clearances applicable to your specific model.

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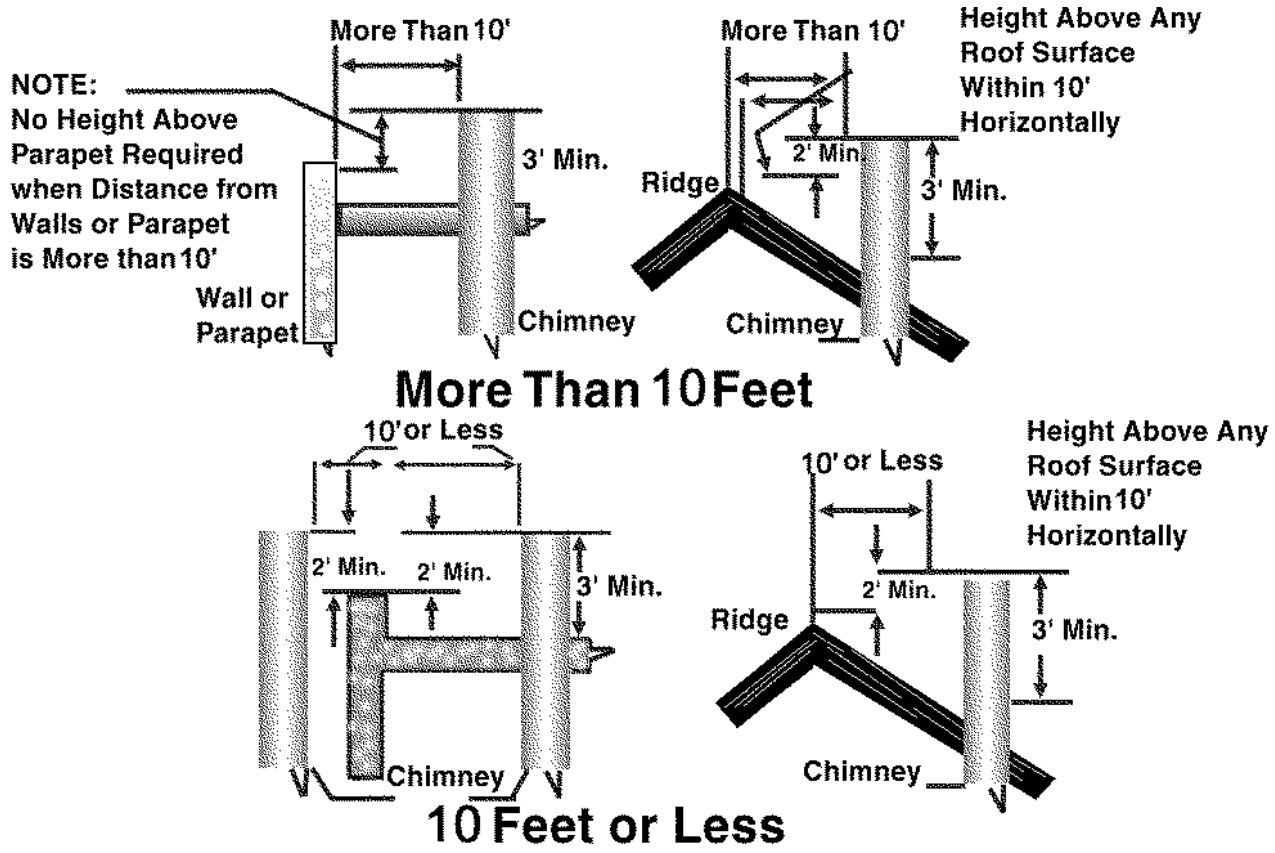
EXTERIOR CLEARANCE



"Copyright by the American Gas Association. Used by permission of the copyright holder".

This illustrates the exterior roof clearances for BTR units with natural draft venting. The vent shall extend at least 3 feet above the highest point where it passes through a roof of a building, and at least 2 feet higher than any portion of a building within a horizontal distance of 10 feet (for vents of 12" in diameter or less). (NFPA 54 ANSI Z 223.1 SEC 7.5.2a). (Sec 7.6.2a may allow reduction to 8 feet with a " Listed vent cap").

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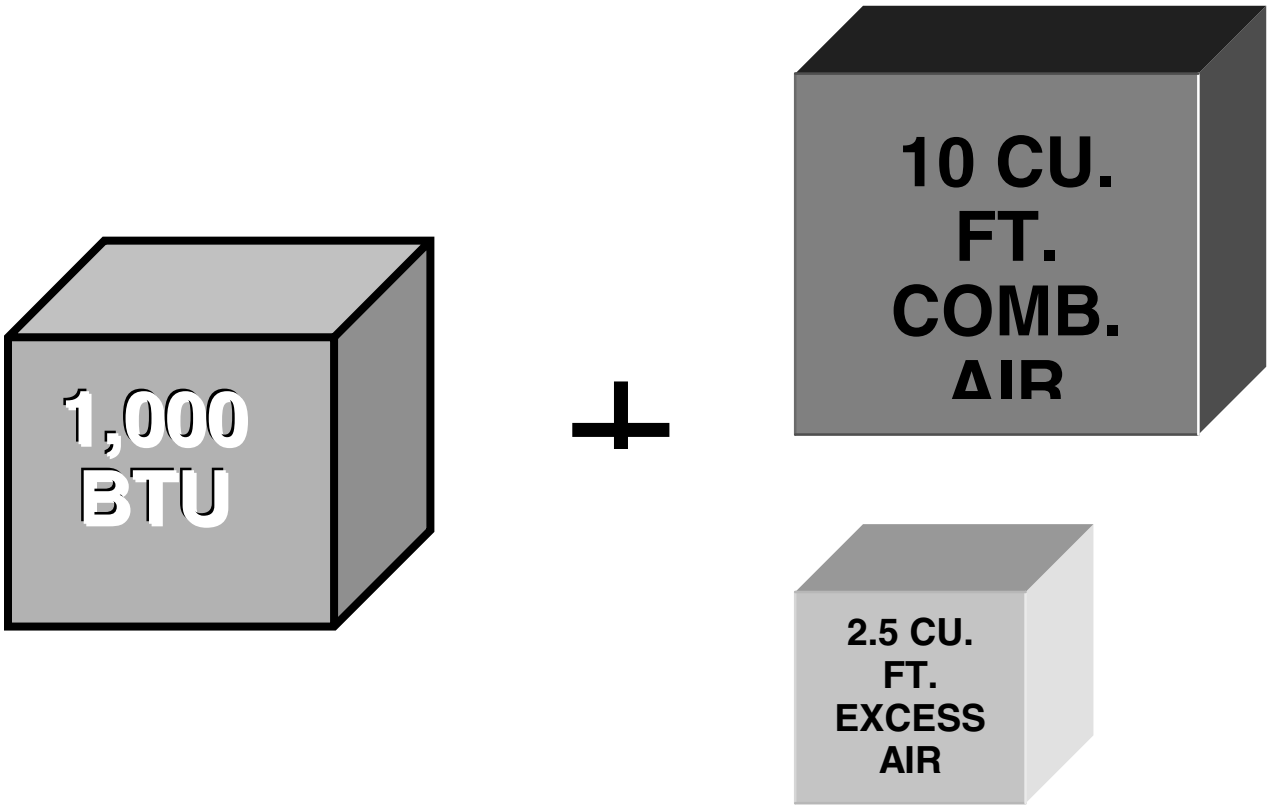
AIR FOR COMBUSTION
10 CUBIC FEET OF AIR PER 1,000 BTU



Stoichiometric or theoretical complete combustion requires 10 cubic feet of air per 1000 BTUH input of the gas input. The National Fuel Gas Code also recommends an additional 2.5 cu.ft. of "excess" air. This 12.5 cu.ft minimum supply air per 1000 BTUH input applies to natural and propane gas models.

The National Fuel Gas Code also specifies minimum make-up air opening sizes for various building installations. (Ref: NFPA 54, ANSI Z223.1, sec 5.3)

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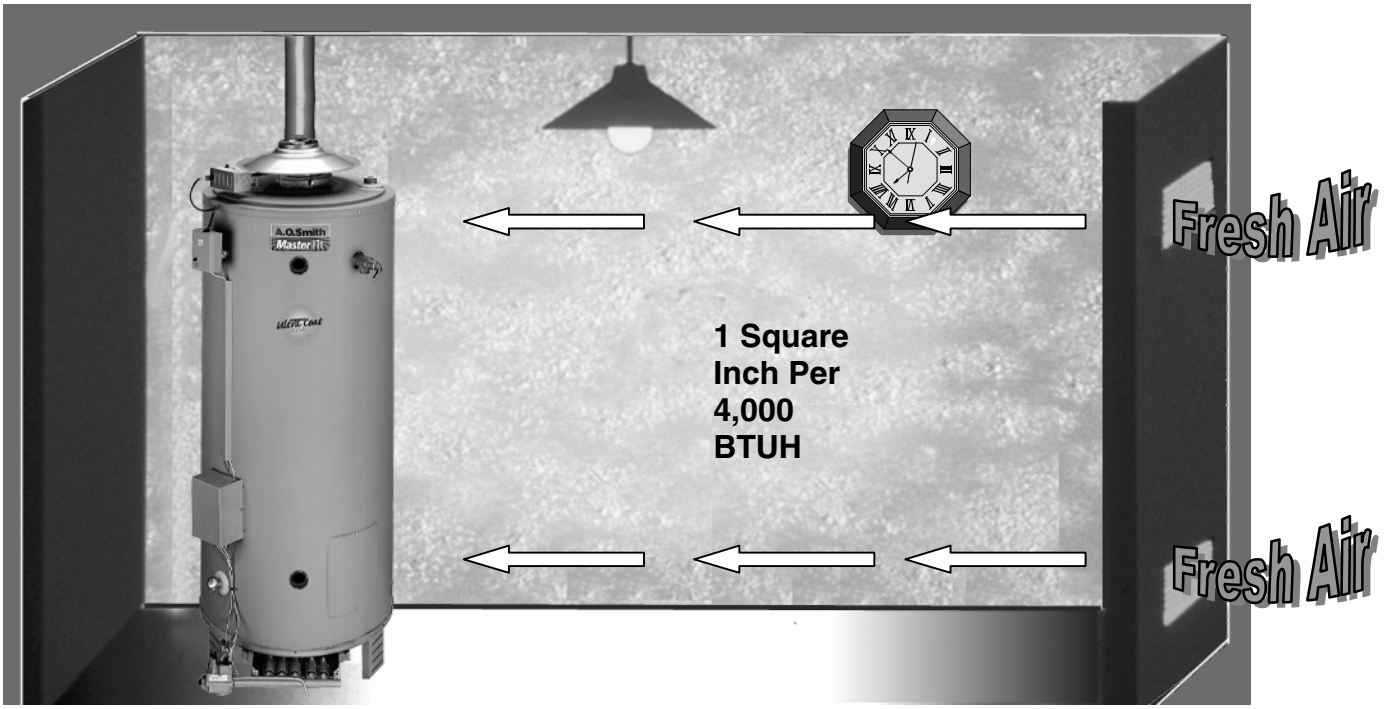
MAKE-UP AIR
DIRECT COMMUNICATION



A fresh supply of make-up air for combustion can be supplied to the heater through make-up air ducts which directly communicate with the out of doors. Two openings are required - one within 12 inches of the top of the enclosure and one within twelve inches of the bottom of the enclosure. Each opening shall have a free area of not less than 1 square inch per 4000 BTUH of the total input of all appliances within the enclosure.

The lower opening is primarily providing combustion air. The upper opening is providing vent dilution air and acts as a relief opening for flue gases should the vent become obstructed or a downdraft condition occur. Additionally, when the heater is installed in a confined space and communicating with the outdoor air, one permanent opening, commencing within 12 in. (30 cm) of the top of the enclosure, shall be permitted where the equipment has clearances of at least 1 in. (2.5 cm) from the sides and back and 6 in. (16 cm) from the front of the appliance. The opening shall directly communicate with the outdoors and shall communicate through a vertical or horizontal duct to the outdoors or spaces (crawl or attic) that freely communicate with the outdoors, and shall have a minimum free area of:

a. 1 sq. in. per 3000 BTU per hr (7 cm^2 per kW) of the total input of all equipment located in the enclosure, and
b. Not less than the sum of the areas of all vent connectors in the confined space.

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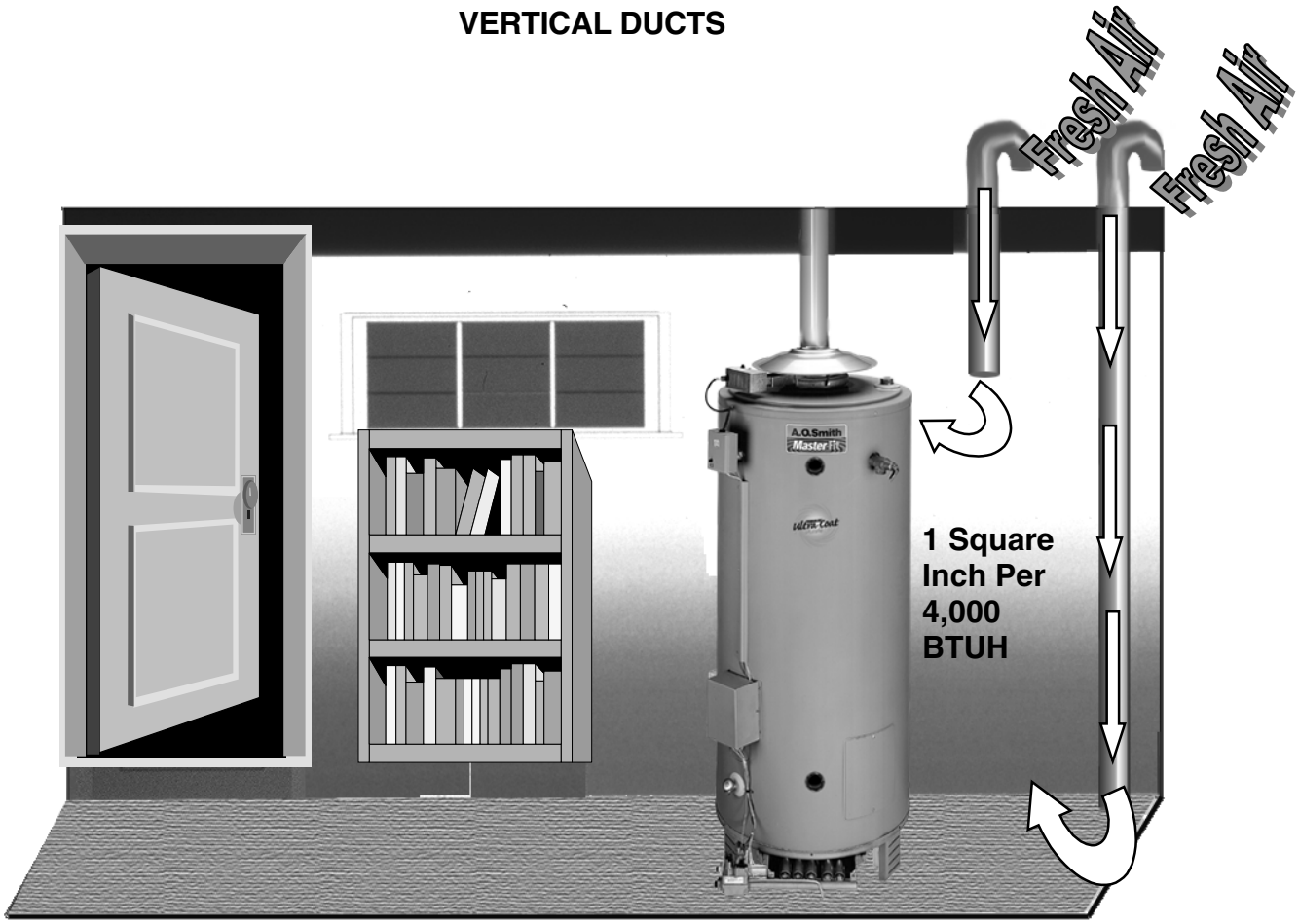
MAKE-UP AIR
VERTICAL DUCTS



Often it is more practical to install vertical make-up air ducts to the out doors. Again, two openings are required - one within 12 inches of the top of the enclosure and one within twelve inches of the bottom of the enclosure. Each opening shall have a free area of not less than 1 square inch per 4000 BTUH of the total input of all appliances within the enclosure.

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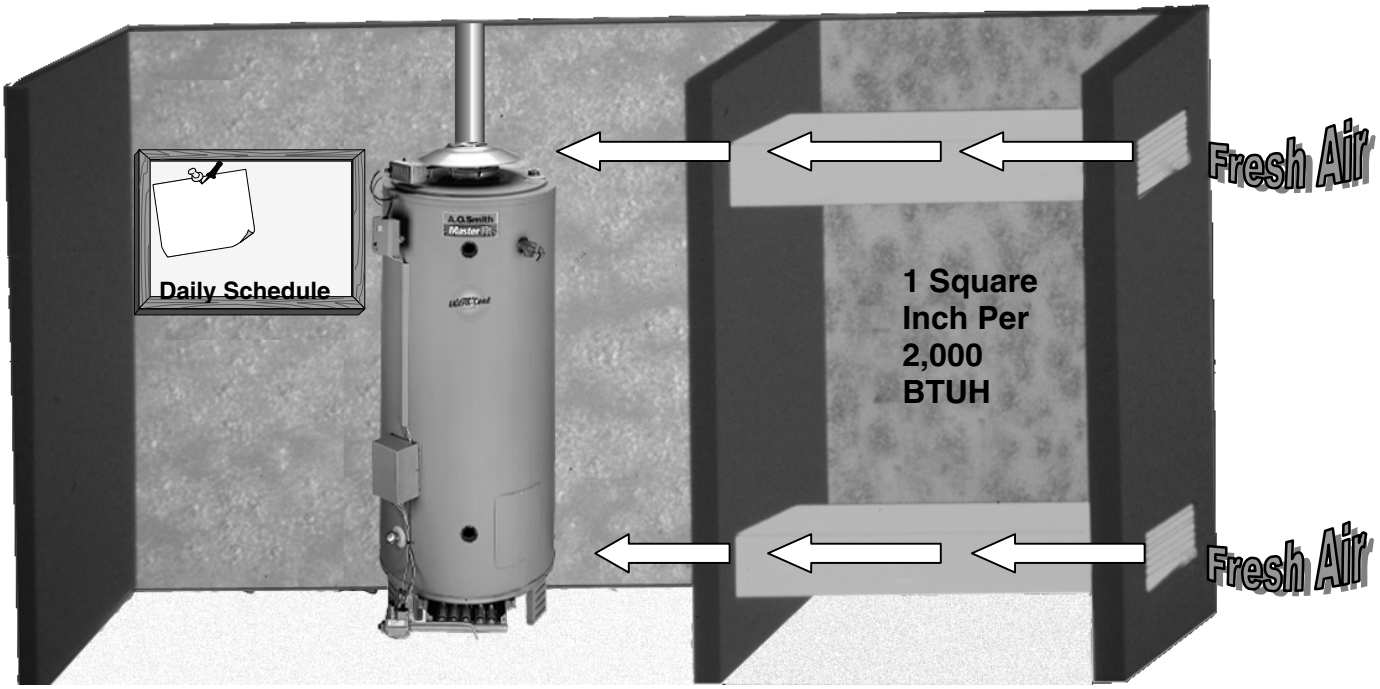
MAKE-UP AIR
HORIZONTAL DUCTS



When the heater is installed in an interior room with no roof access for vertical ducts, horizontal make-up air ducts should be installed. When using horizontal ducts, two openings are required - one within 12 inches of the top of the enclosure and one within twelve inches of the bottom of the enclosure. Each opening shall have a free area of not less than 1 square inch per 2000 BTUH of the total input of all appliances within the enclosure.

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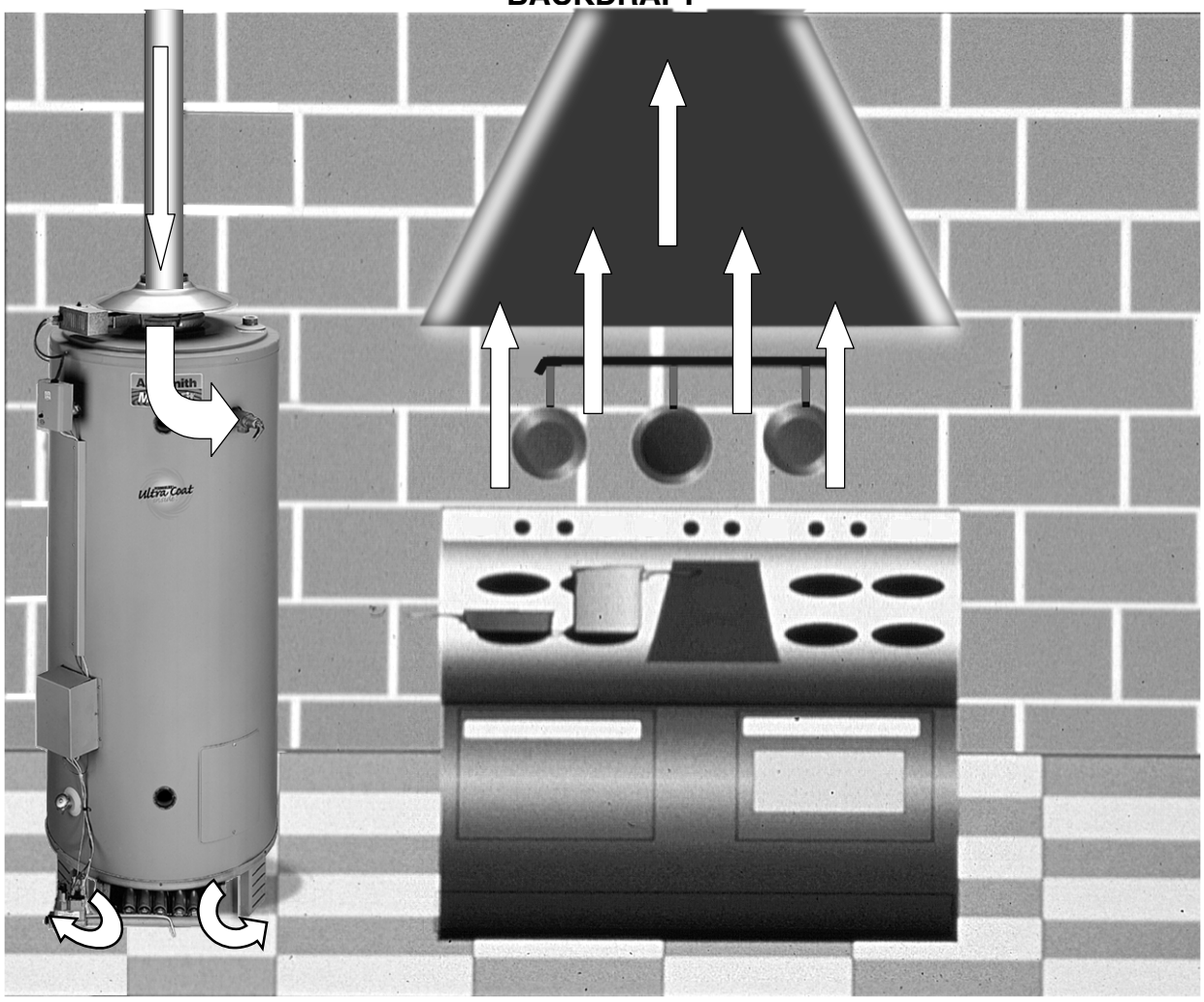
INSUFFICIENT MAKE-UP AIR
BACKDRAFT



Insufficient make-up air is a major cause of combustion problems. One common example is in a restaurant installation where exhaust vent equipment was not considered in sizing make-up air requirements. This may result in air being backdrafted by the restaurant exhaust equipment through the heater causing flue gas spillage, flame roll out, improper combustion, inconsistent pilot operation, and/or erratic heater shut down.

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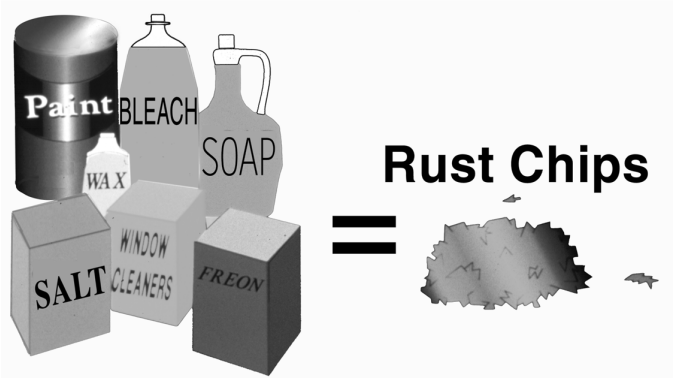
CONTAMINATED AIR



Along with adequate make-up air, the quality of the air is important. Contaminants in combustion air can lead to premature heater failure. Vapors from bleaches, soaps, waxes, salts, etc. are drawn into the combustion chamber with the make-up air and, once fired, mix with water vapor in the gases to form extremely corrosive hydrochloric or hydrofluoric acid and other corrosive byproducts.

AIR FOR COMBUSTION
Flammable Items

Flammable items, pressurized containers or any other potentially hazardous articles must never be placed on or adjacent to the heater. Open containers of flammable material should not be stored or used in the same room with the heater.

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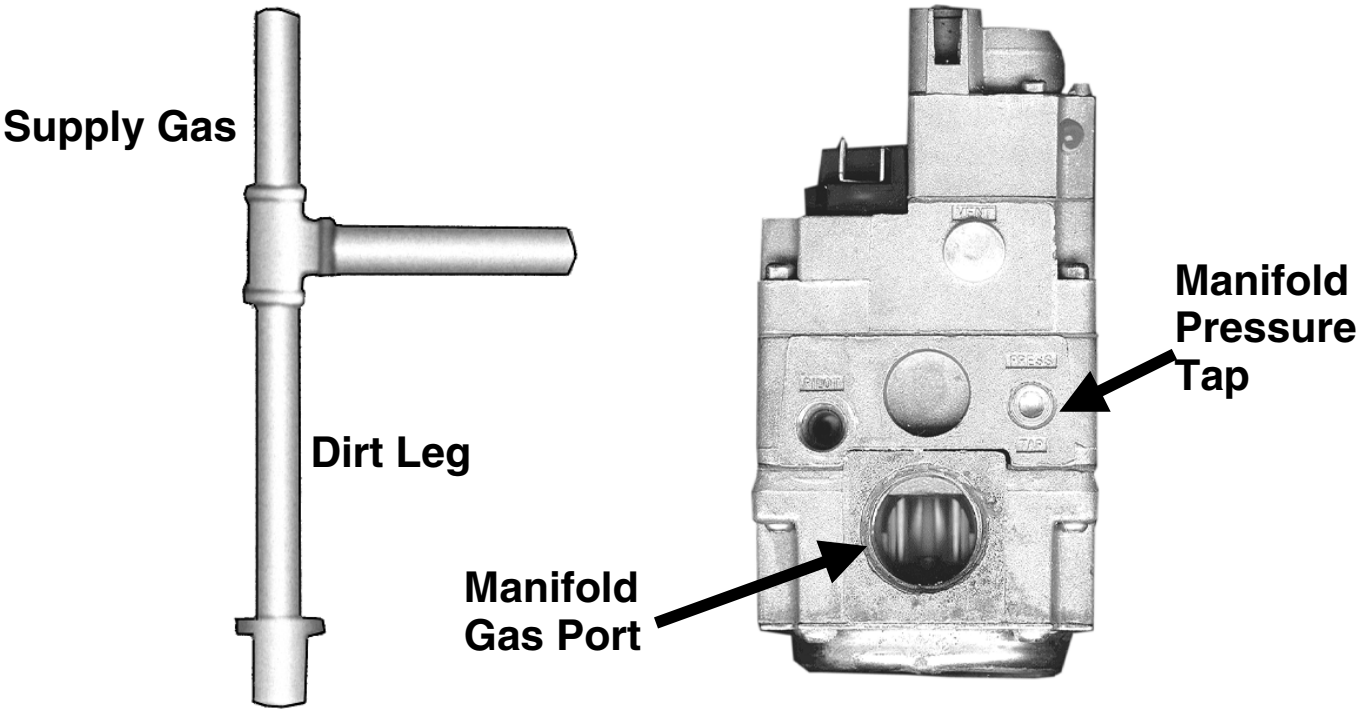
GAS PRESSURE REQUIREMENTS



	Natural Gas	Propane Gas
Maximum Supply Pressure	13.8" w.c.	13.8" w.c.
Minimum Supply Pressure	4.5" w.c.	11" w.c.
Manifold Pressure	3.5 " w.c.	10" w.c.

The supply gas pressure is normally measured at the dirt leg or at the gas pressure tapping on the gas supply shutoff valve. This reading must be measured with 'flowing' gas.

The manifold gas pressure is measured at the manifold pressure tap of the gas valve when the gas is flowing.

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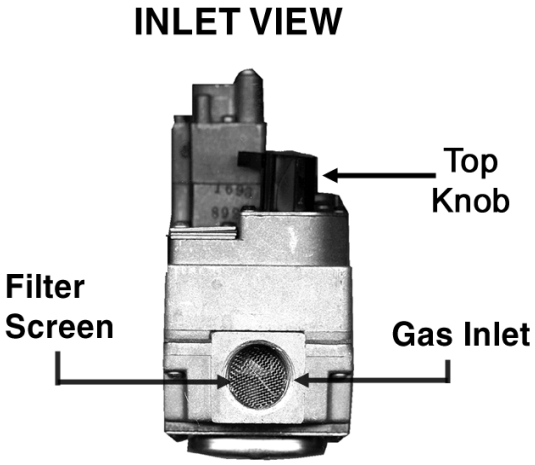
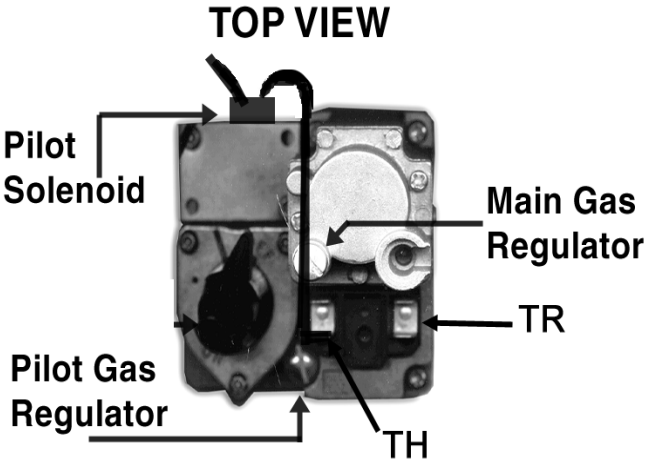
BTR GAS VALVE

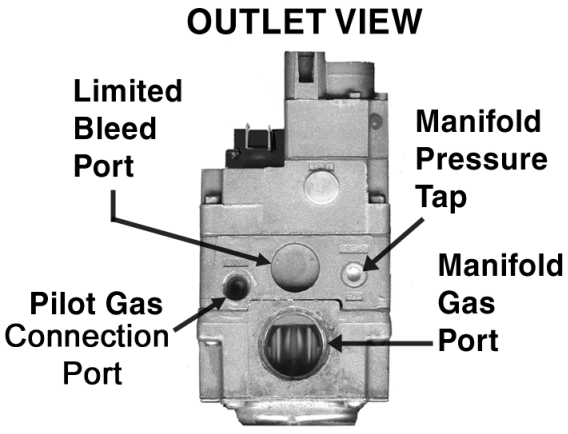
The gas valves used on all BTR water heaters are 24 volt AC combination step opening gas valves. They incorporate the pilot valve, main valve, and gas pressure regulators into one body. The inlet view of the valve features a filter screen and the top knob. The top knob is a manual on/off gas control for both the pilot and main gas valves. When the top knob is placed on the black mark, gas is supplied only to the pilot valve.



On the top view, we see the pilot solenoid and pilot and main gas regulators. The top view also displays the "TH and "TR" terminals. The pilot gas regulator is found under its cover screw. It is factory preset at 3.5"w.c. but can be adjusted from 2.5 to 5 inches water column. The main gas regulator is found under its cover screw. It is factory preset to 3.5 inches w.c. and adjusts gas pressure output from 2.5 to 5 inches water column. The two electrical terminals are marked TH and TR. The TH terminal is the common between the pilot valve solenoid coil and the main valve solenoid coil. The other wire emerging from the pilot solenoid connects to the pilot valve electrical output on the IID (terminal PV). The TR terminal connects directly to the main valve electrical output from the IID module (terminal MV).



On the outlet view of the gas valve, we see the pilot gas connection port, manifold gas connection port, a limited bleed vent port, the manifold gas and pressure tap.
See step 18 for BTR-500 gas valve illustration



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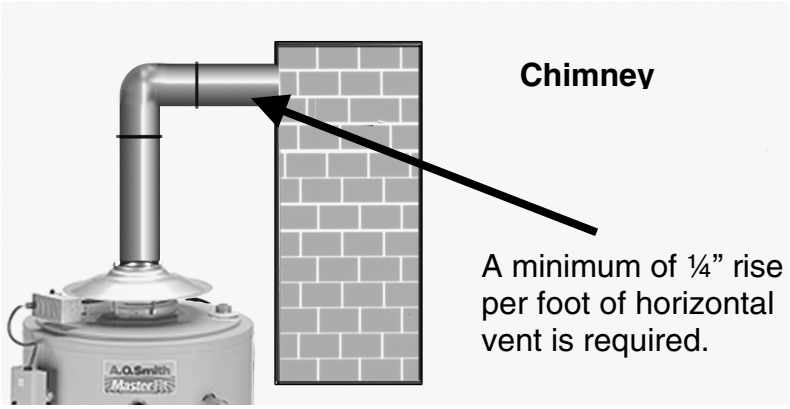
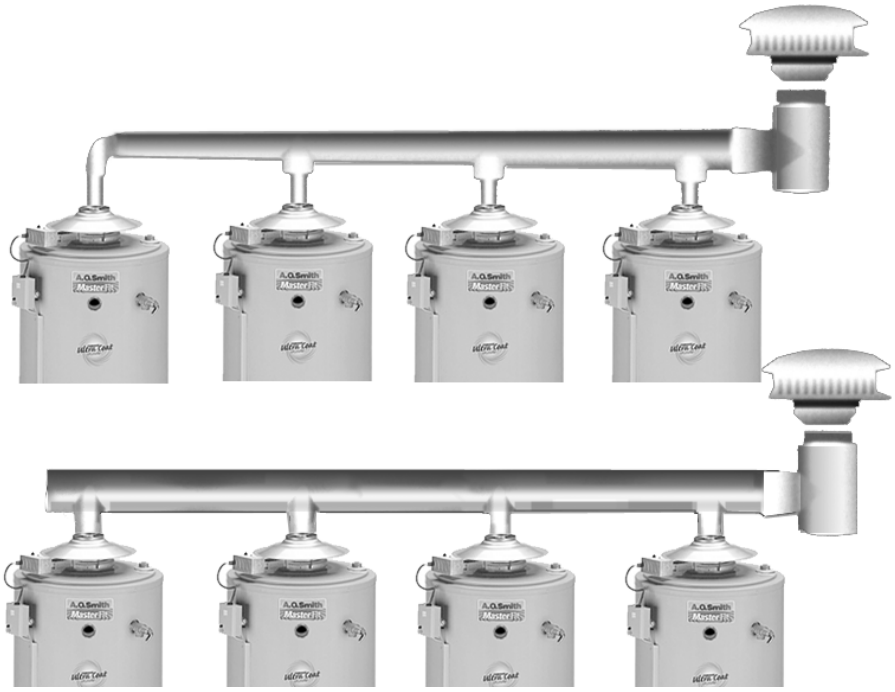
VENTING
Atmospheric Multiple Heaters





All BTR water heaters are classified by ANSI as category I (non-condensing, negative pressure venting) appliances. They are approved for type B vent.

For larger applications, BTR water heaters can be common vented together either in a tapered manifold or constant size manifold. (Follow National Fuel Gas Code requirements for sizing and installation.)

BTRs may be common vented only with other category I appliances. (See venting section in the National Fuel Gas Code).

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DRAFT INDUCER

Draft inducers can be used with BTR water heaters to mechanically aid a lazy chimney in vertical vent applications. They are not designed to allow “through-the-wall” vent installations. (See Power Venter)

SINGLE UNIT INSTALLATION

When mechanically venting, the following items are required:

Qty	Description	Part No.
1	Draft Inducer (up to 300,000Btuh)	90909
1	Draft Inducer (up to 305,000 thru 500,000 Btuh)	90910
1	Draft Prover Switch	95220
1	Relay Switch	96695

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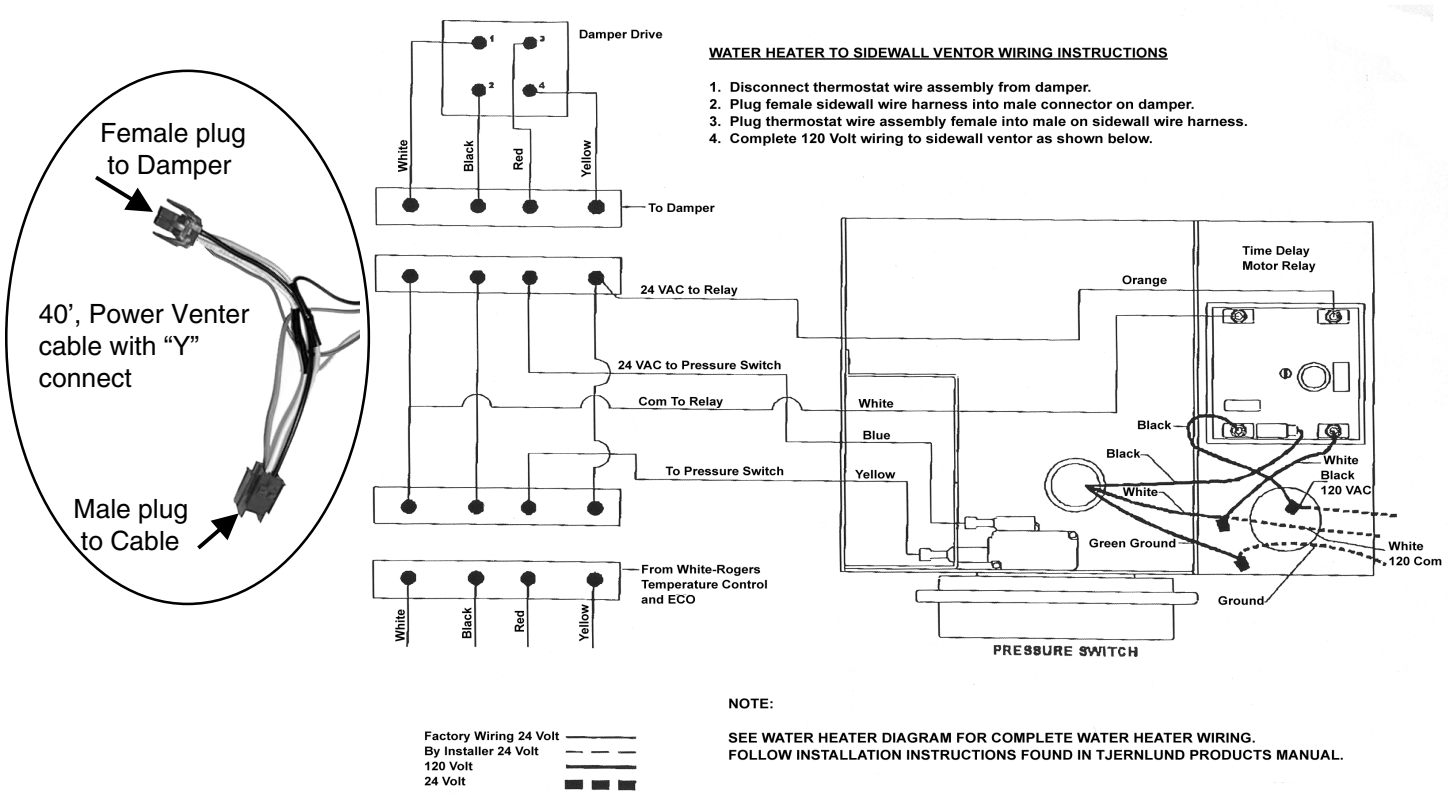
POWER VENT KITS FOR SIDEWALL VENTING



Water Heater Models	Part Number
BTR-120-200	193933-0
BTR-250-500	193933-1

BTR water heaters can be used with power vent kits for sidewall venting. A.O. Smith offers power vent kits for use on installations with a maximum of 100 equivalent feet of vent piping. The power vent kits also use type B vent materials. When power venting, specific exterior clearances must be maintained, as outlined in the National Fuel Gas Code. (NFPA 54, ANSI A223.1, sec 7.8)

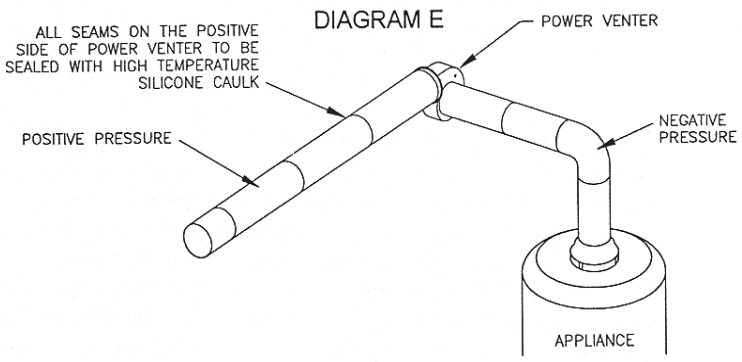


DIAGRAM E
POWER VENTER
ALL SEAMS ON THE POSITIVE SIDE OF POWER VENTER TO BE SEALED WITH HIGH TEMPERATURE SILICONE CAULK
POSITIVE PRESSURE
NEGATIVE PRESSURE
APPLIANCE

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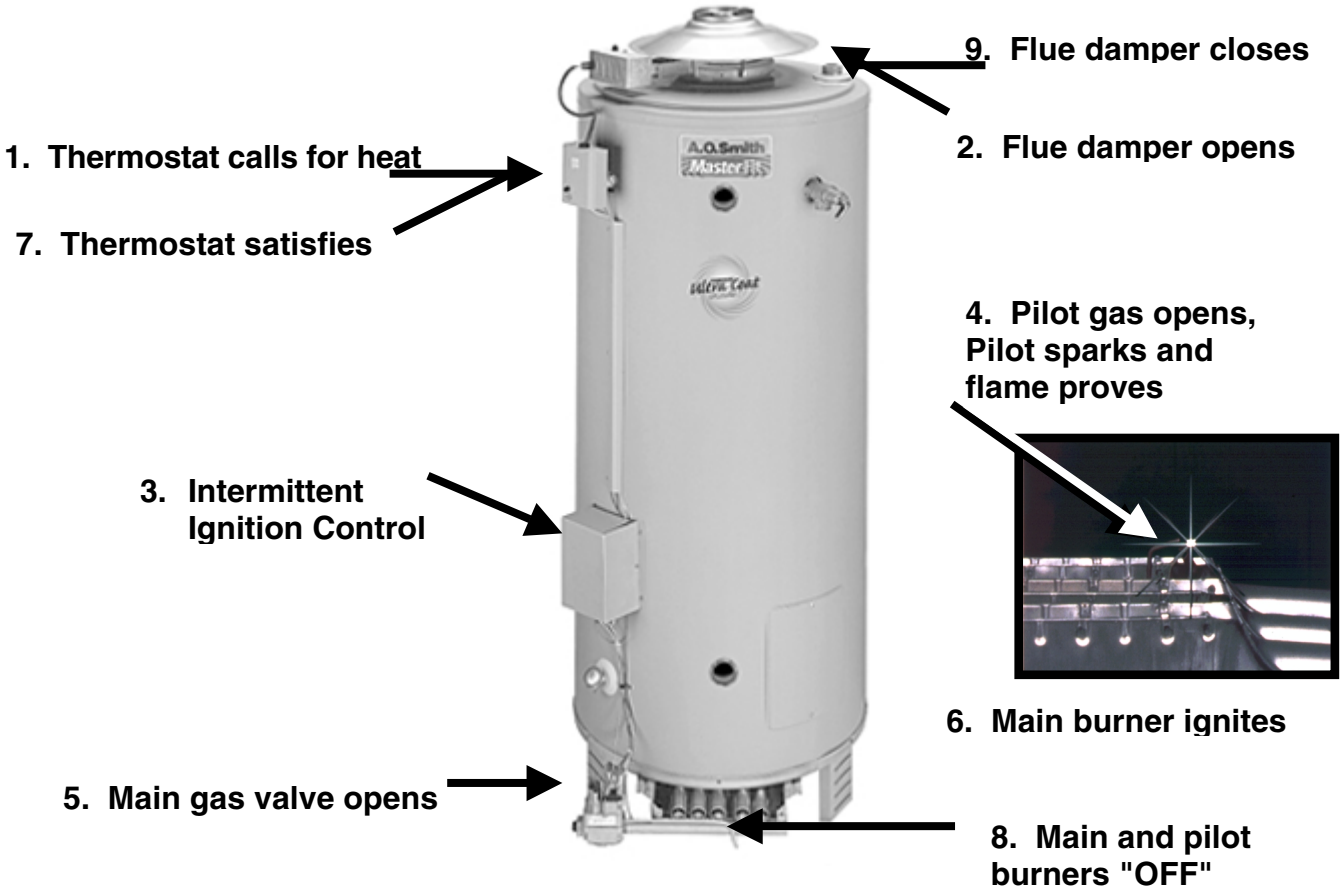
BTR SEQUENCE OF OPERATION


9. Flue damper closes
1. Thermostat calls for heat
2. Flue damper opens
7. Thermostat satisfies
4. Pilot gas opens, Pilot sparks and flame proves
3. Intermittent Ignition Control
6. Main burner ignites
5. Main gas valve opens
8. Main and pilot burners "OFF"

SEQUENCE OF OPERATION

To understand BTR tank type water heaters, an examination of their sequence of operation is necessary.

When the thermostat calls for heat, the relay in the draft hood assembly activates, de-energizing the flue damper motor. The damper opens and power flows to the IID (Intermittent Ignition Device). This activates the IID module to open the pilot valve and begin sparking at the pilot burner assembly. Once the pilot flame is established and confirmed back to the IID, the sparking is stopped and the main gas valve is opened, allowing gas flow to the main burner. When the thermostat satisfie's, main and pilot gas is shut off.

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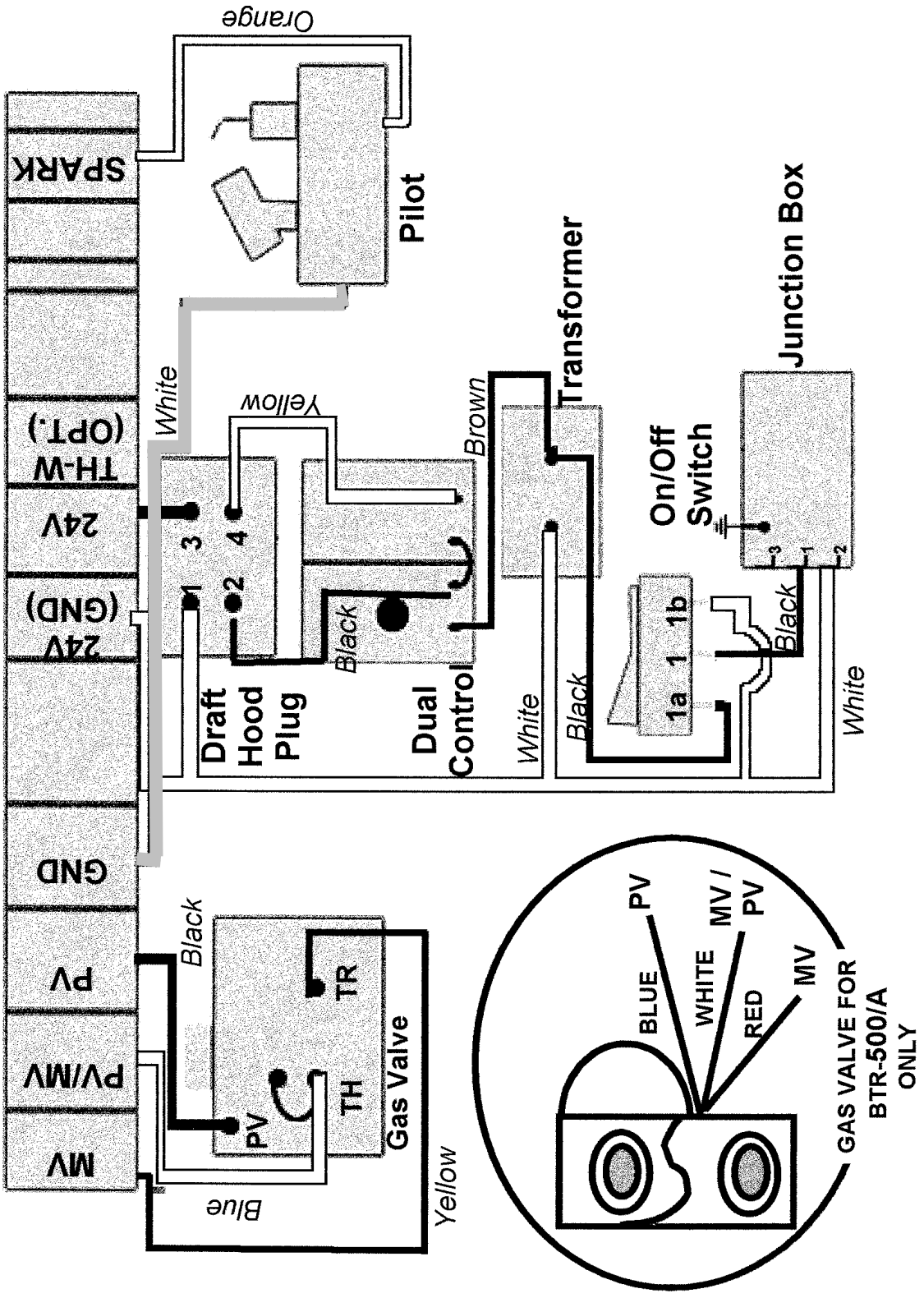
BTR ELECTRICAL SEQUENCE
100 – 109 Series



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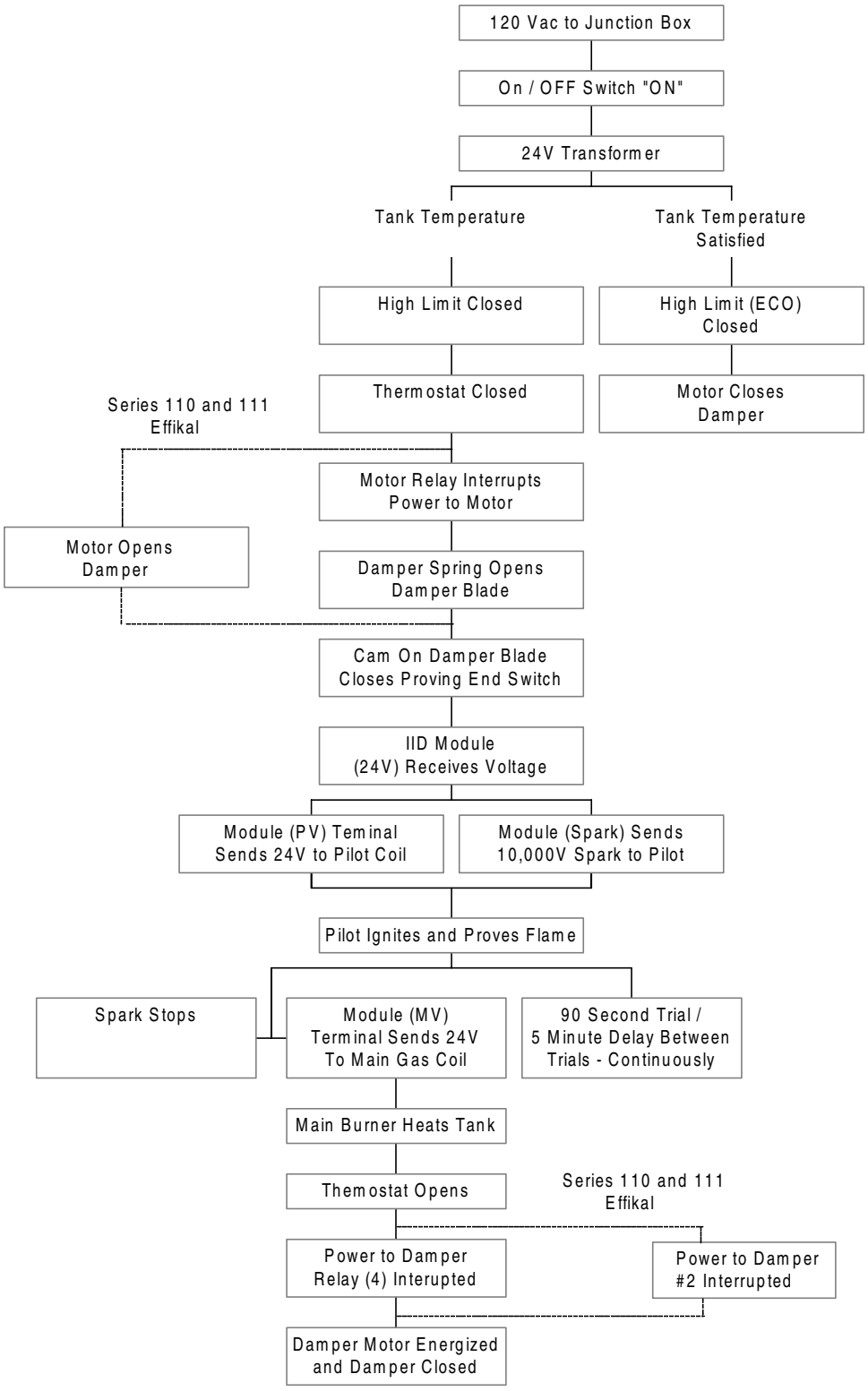
BTR ELECTRICAL SEQUENCE OF OPERATION


120 Vac to Junction Box
On / OFF Switch "ON"
24V Transformer
Tank Temperature
Tank Temperature Satisfied
High Limit Closed
High Limit (ECO) Closed
Thermostat Closed
Motor Closes Damper
Series 110 and 111 Effikal
Motor Relay Interrupts Power to Motor
Motor Opens Damper
Damper Spring Opens Damper Blade
Cam On Damper Blade Closes Proving End Switch
IID Module (24V) Receives Voltage
Module (PV) Teminal Sends 24V to Pilot Coil
Module (Spark) Sends 10,000V Spark to Pilot
Pilot Ignites and Proves Flame
Spark Stops
Module (MV) Terminal Sends 24V To Main Gas Coil
90 Second Trial / 5 Minute Delay Between Trials - Continuously
Main Burner Heats Tank
Themostat Opens
Series 110 and 111 Effikal
Power to Damper Relay (4) Interupted
Power to Damper #2 Interrupted
Damper Motor Energized and Damper Closed

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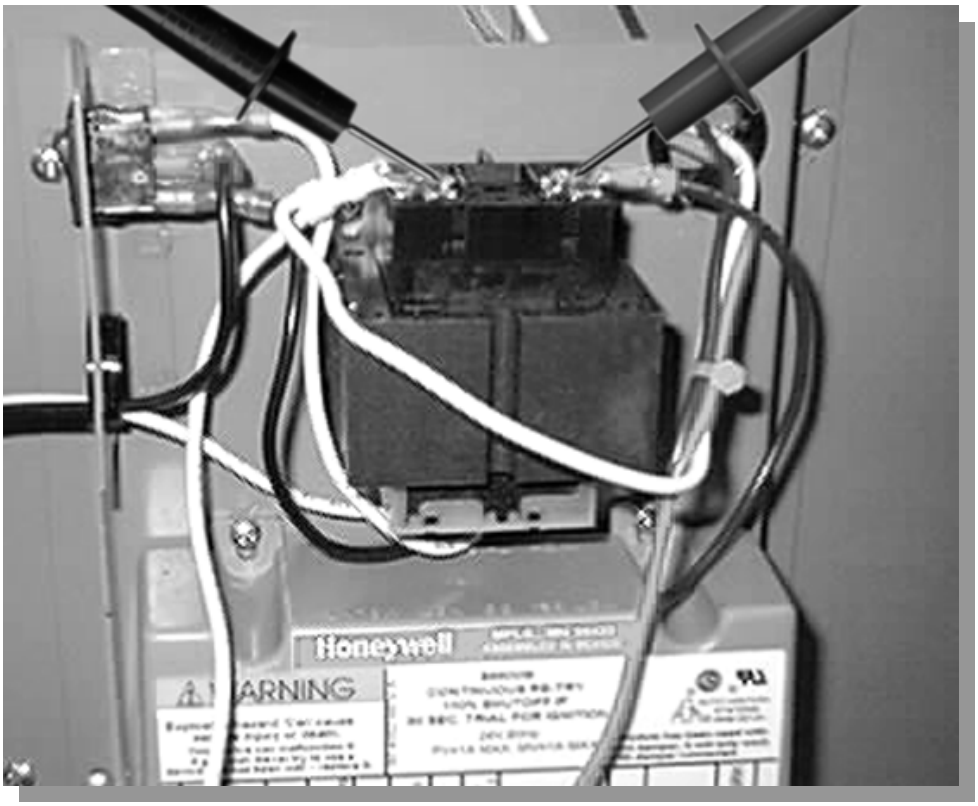
TROUBLESHOOTING BTR WATER HEATERS

To troubleshoot a BTR water heater check that:

- 120 VAC is supplied to the heater
- the tank is full of water
- gas is supplied to the unit

STEP 1	TEST THE TRANSFORMER



STEP 1 - TO TEST THE TRANSFORMER - Using a multimeter, test for 24 VAC between the secondary transformer terminals.

IF	THEN
The meter does not read 24 VAC:	• Check that the 120 VAC is supplied from the On/Off Switch – if not, replace switch. • Check that the 120 VAC is supplied from transformer.
The meter reads 24 VAC:	• Go to step 2.

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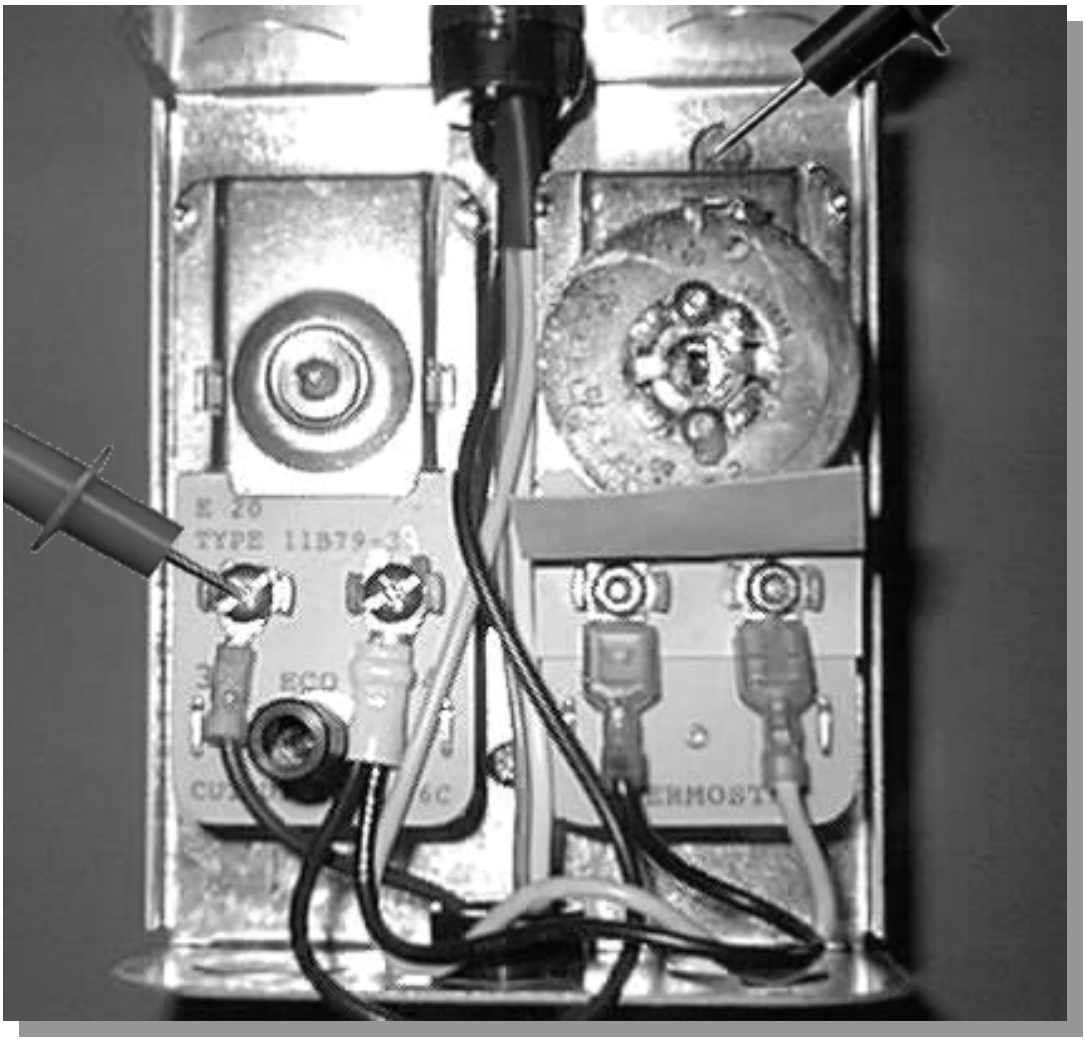
STEP 2 HIGH LIMIT, LEFT TERMINAL TEST



STEP 2. HIGH LIMIT, LEFT TERMINAL TEST. Test for 24 VAC between the left high limit terminal and ground.

IF	THEN
The meter does not read 24 VAC:	• Check wiring between transformer and high limit.
The meter reads 24 VAC:	• Go to Step 3.

Note: The high limit (Energy Cut Off) opens if the tank water temperature exceeds 205 degrees. The control is resettable (manually) when the tank water temperature drops below 185 degrees.

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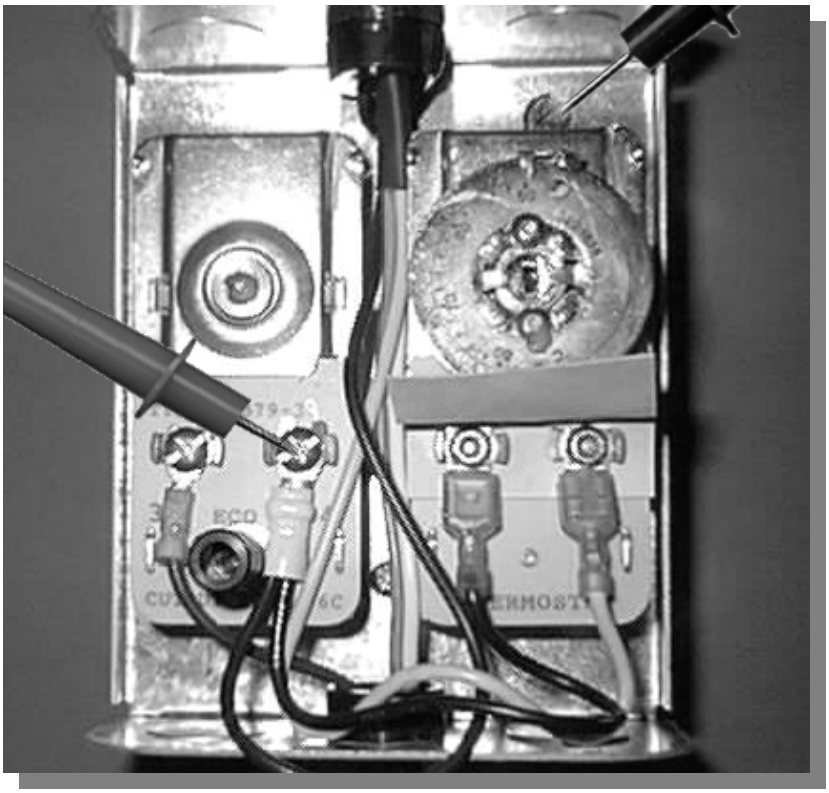
STEP 3 TEST HIGH LIMIT RIGHT TERMINAL



STEP 3. TO TEST HIGH LIMIT RIGHT TERMINAL. Ensure that the jumper wire between the high limit and thermostat is connected, and the damper motor power line is connected. Test for 24 VAC between the high limit right terminal and ground.

IF	THEN
The meter does not read 24 VAC:	• Push the reset button and redo the test (storage water temperature below 185 degrees).
The meter reads 24 VAC:	• Go to step 4.

After Push in Reset - 24 VAC is now present

Reasons For Resetting

Condition	Cause	Solution
High limit open	Never set on initial installation	Push high limit button
Excessive water temperature	Faulty thermostat	Replace dual control
Heater shut down before reaching thermostat setting	Faulty high limit	Replace dual control

Note: The right terminal of the high limit has a jumper wire connected to the left terminal of the thermostat. There is also a black wire connecting to the damper motor assembly. This black wire supplies power to the motor to close the damper during periods of standby.

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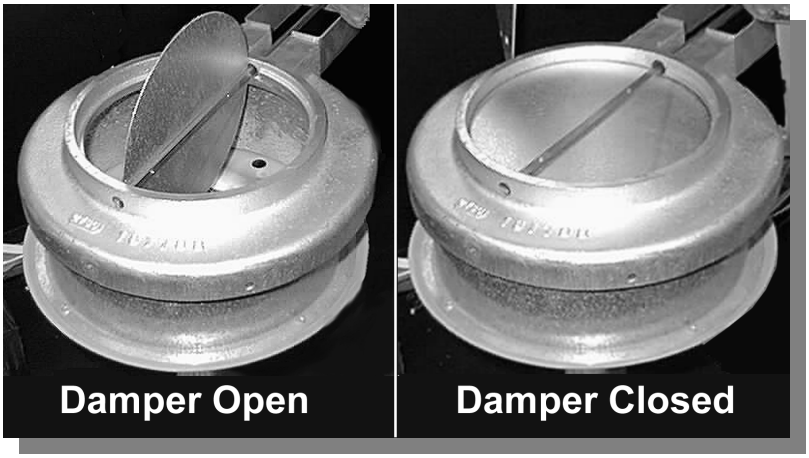
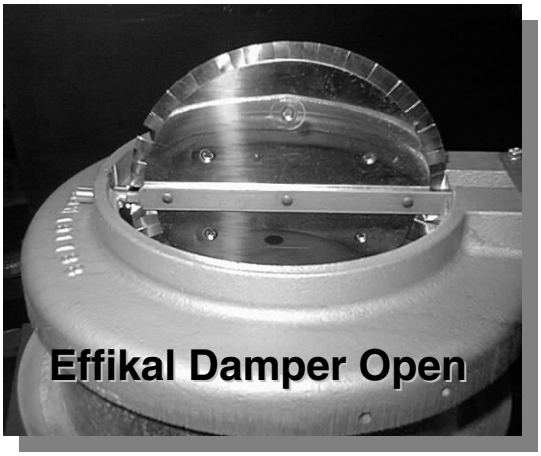
STEP 4 INSPECT THE DAMPER



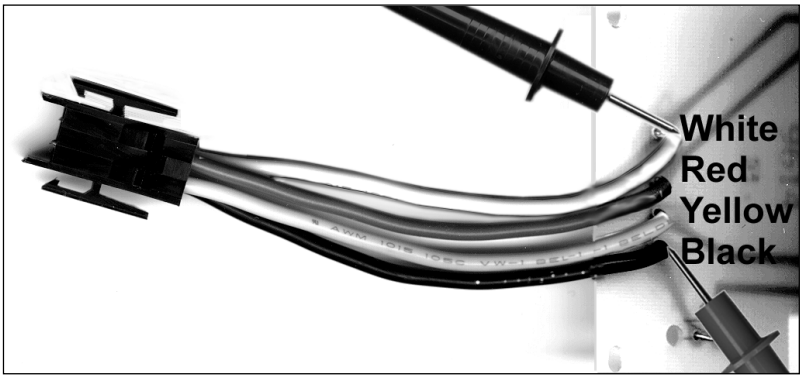


STEP 4. INSPECT THE DAMPER. Lower the thermostat setting so the unit will not be calling for heat, then inspect the damper.

IF	THEN
If the damper is open:	• Go to step 5.
If the damper is closed:	• Go to step 7.

Note: If the water temperature in the tank is below 120 degrees F, temporarily disconnect the jumper wire between the high limit and thermostat to simulate a satisfied thermostat.

STEP 5 CHECK THE PC BOARD



STEP 5. CHECK THE PC BOARD. Test for 24 VAC between the black PC board wire connection and ground.

IF	THEN
24 VAC is not present:	• Check the black wire connections between PC Board and high limit.
24 VAC is present:	• Go to step 6.

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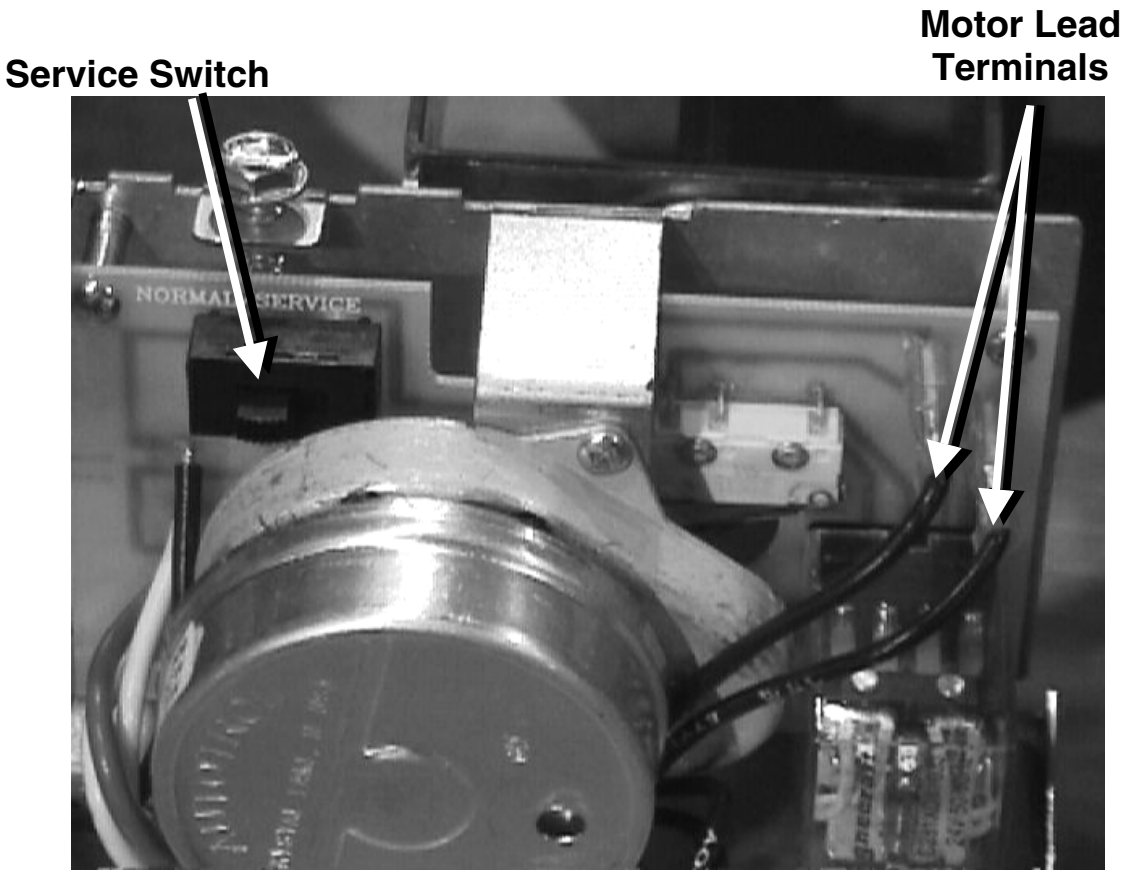
STEP 6 PC BOARD MOTOR TEST



STEP 6. PC BOARD/MOTOR TEST. Check for 24 VAC between the two motor lead terminals of the PC board. Disconnect the wires for this test.

IF	THEN
24 VAC is not present:	• Replace the board (AOS part # 6522) and go to step 7. The board and relay are one piece. Regardless of which part is defective, both parts should be changed.
Voltage is present:	• This verifies that the motor is receiving power but not closing the damper. • Replace the motor (AOS part # 6521) and go to step 7.

Note: The service switch may be used to bypass the damper, while waiting for a replacement part.

WARNING - In the event of damper motor failure, verify that the damper is in the "open" position before utilizing the service switch. (BTR Series 106/107 and some prior series – changed from momentary push button to service switch).

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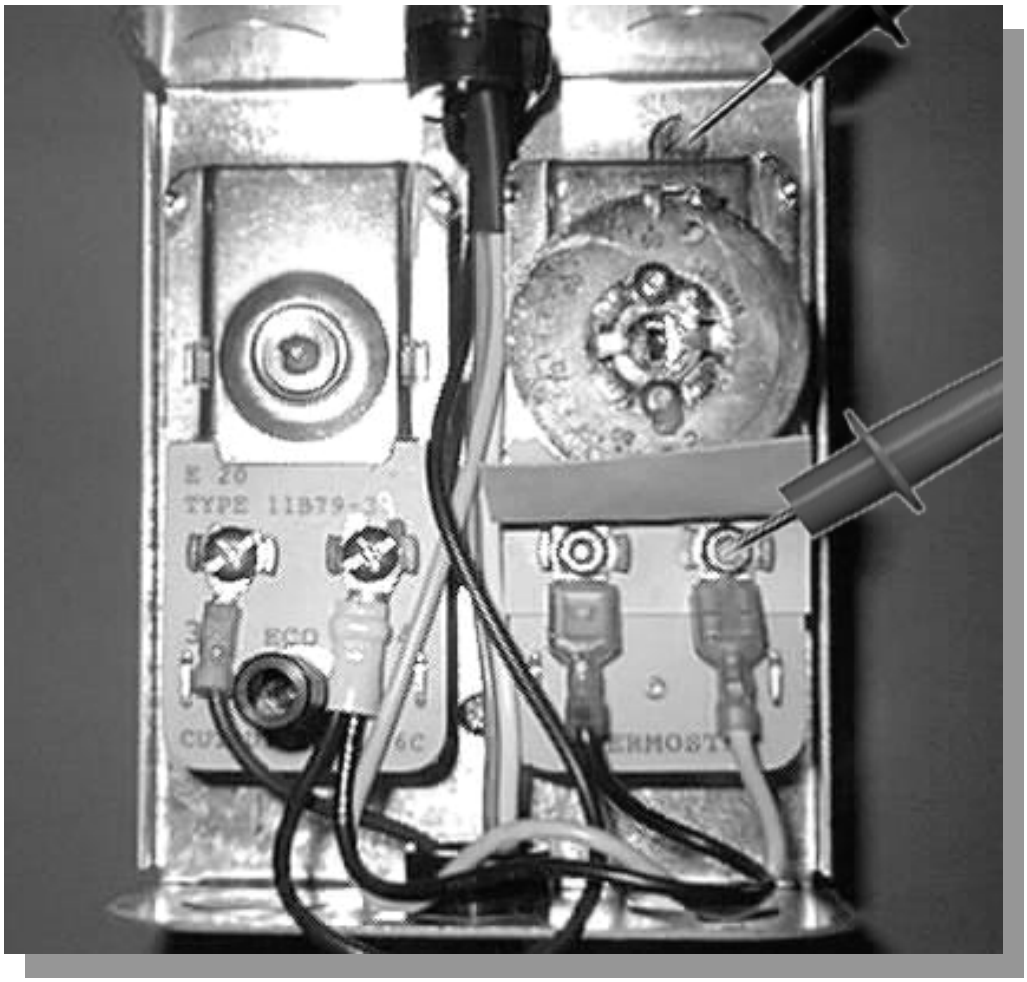
STEP 7 THERMOSTAT TEST



STEP 7. THERMOSTAT TEST. Set the thermostat to call for heat. Using your multimeter, test for 24 VAC between right terminal and ground.

IF	THEN
The meter does not read 24 VAC and the jumper wire between the high limit and the thermostat is in place:	• Replace the thermostat
The meter reads 24 VAC:	• Go to step 8.

Note: If the high limit to thermostat jumper wire was disconnected earlier to simulate a satisfied thermostat, reconnect the jumper to the terminals.

Note: A yellow wire from this thermostat terminal connects to the damper PC board.

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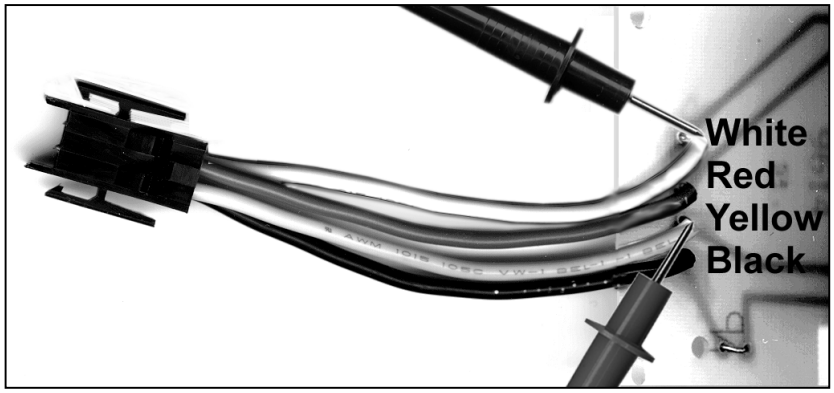
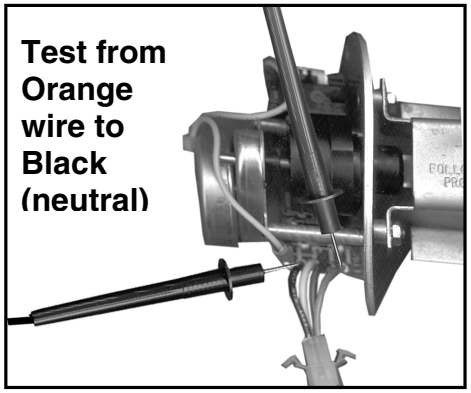
GO TO PAGE 27 FOR DAMPER TESTS OF EFFIKAL EQUIPPED (SERIES 110, 111 AND RETROFIT) MODELS

STEP 8 DAMPER INPUT TEST





STEP 8. DAMPER INPUT TEST. Test for 24 VAC between the yellow wire on the PC board and ground. Effikal – Check from orange wire to neutral

IF	THEN
24 VAC is not present:	• Check the black wire connections between the PC board and high limit.
24 VAC is present	• Go to step 6.

STEP 9 TEST THE DAMPER

STEP 9. TEST THE DAMPER. Visually check the damper blade position.

IF	THEN
The damper does NOT open fully:	• Replace the damper assembly
The damper DOES open fully:	• Go to step 10.

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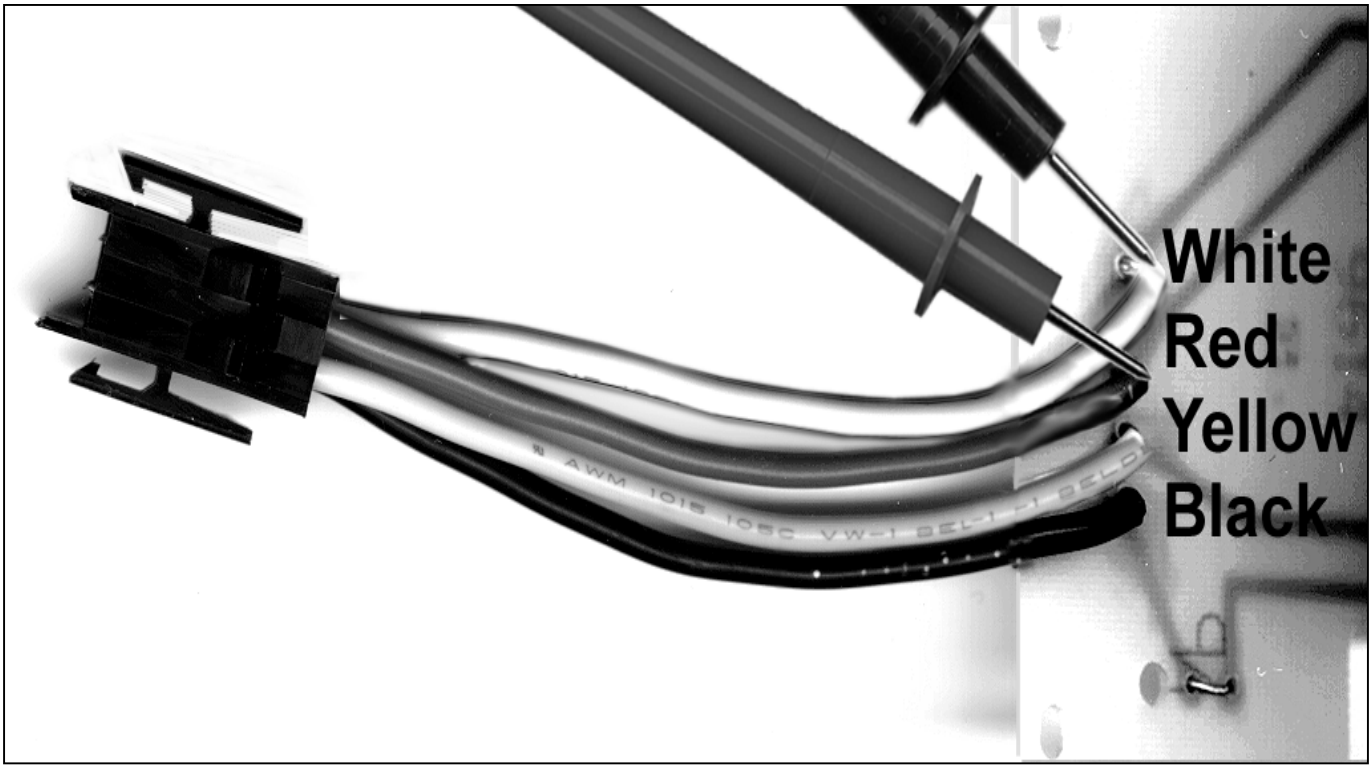
STEP 10 TEST DAMPER OUTPUT



STEP 10. TEST DAMPER OUTPUT. On a call for heat, the damper relays receives power through the yellow wire and power to the motor is interrupted. Then, the motor clutch is disengaged and the damper opens. The damper proves it is open via an end switch before power flows through the red wire from the PC board.

Place the red test probe on the solder joint of the red wire connection to the damper PC board.

IF	THEN
The meter does not read 24 VAC and the end switch is closed:	• Replace the PC board
The meter reads 24 VAC	• Go to step 11.

Note: The spring rotates the damper blade assembly to the open position. This closes an end switch.

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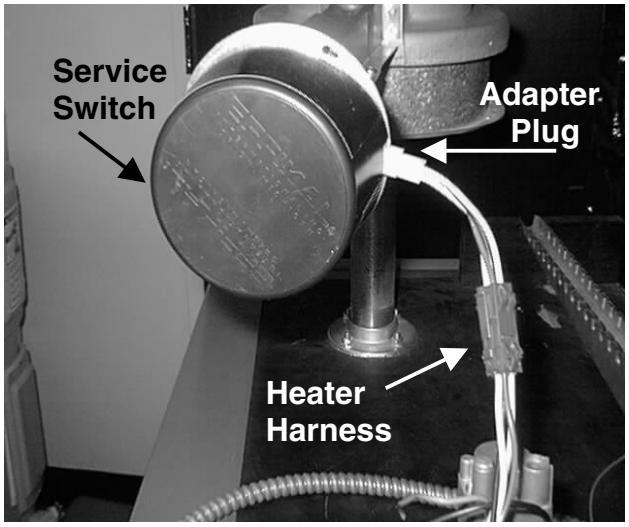
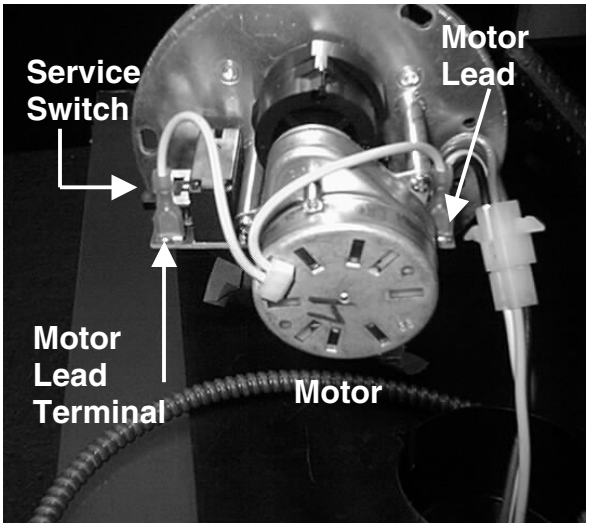
EFFIKAL DAMPER

BTR Series 110 and 111 began using the motor open; motor close, Effikal Damper. The wiring colors from the damper PC Board are different from previous series BTR(C) and BTC Models.



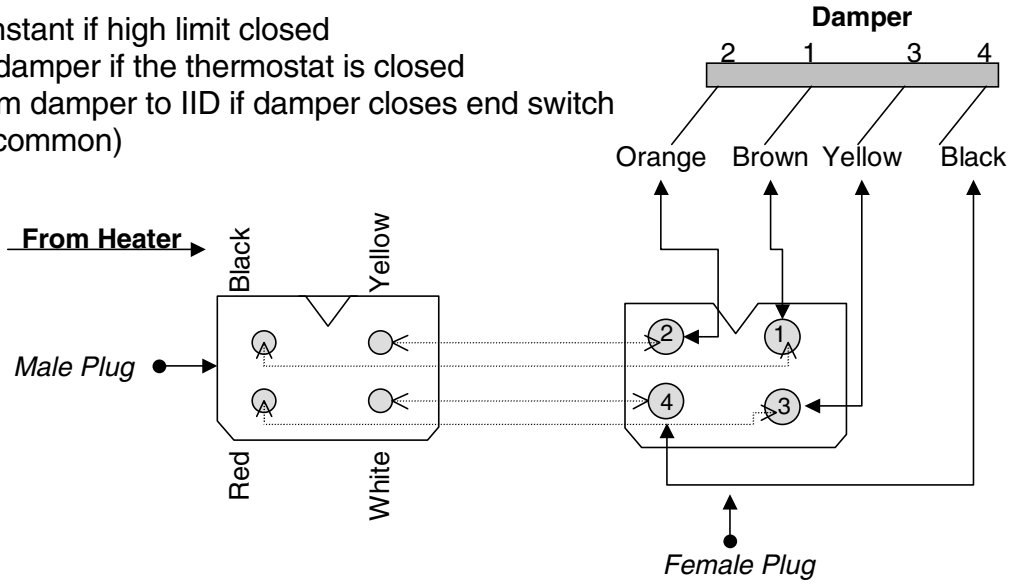
Effikal Control Cover (Photo of kit mounting)



Effikal Style

The heater harness wires still serve the same function:

Black – 24V Constant if high limit closed
Yellow – 24V To damper if the thermostat is closed
Red – 24V From damper to IID if damper closes end switch
White – Neutral (common)



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HARNESS CHART

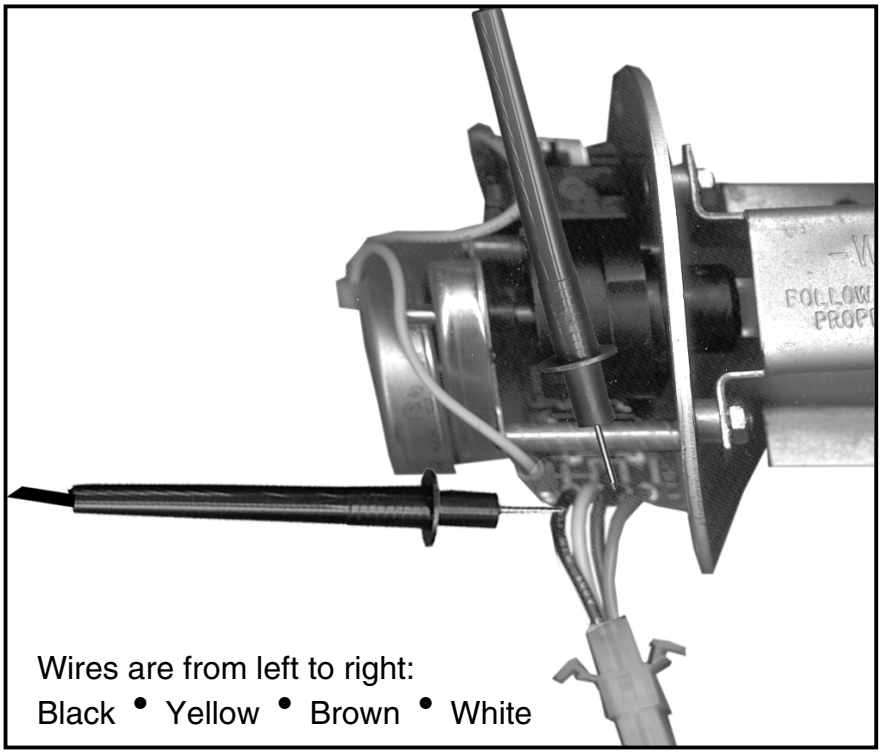
Heater Harness	Function	Damper Harness
Black	24V Hot	1-Brown
Yellow	24V from Therm	2-Orange
Red	24V from damper	3-Yellow
White	24V common	4-Black

Series 110 and 111 heaters and converted model BTR(C) and BTC heaters with Effikal Dampers.

NORMAL OPERATION

Condition:

- Heater on standby
- Damper closed
- High Limit closed



STEP A	TEST FOR 24VAC BETWEEN BLACK (COMMON) AND BROWN

STEP A. TEST FOR 24VAC BETWEEN BLACK (COMMON) AND BROWN

IF	THEN
24VAC is present	Continue to Step B.
24VAC is not present	See Troubleshooting Step A1

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NORMAL OPERATION (continued)

Condition:
- Thermostat closed, damper in process of opening

STEP B	TEST FOR 24VAC BETWEEN BLACK AND ORANGE

IF	THEN
24VAC is present	Continue to Step C.
24VAC is not present	See Troubleshooting Step A2

Condition:
- Thermostat closed, damper fully open

STEP C	TEST FOR 24VAC BETWEEN BLACK AND YELLOW

IF	THEN
24VAC is present	Continue to Step 11
24VAC is not present	See Troubleshooting Step A3

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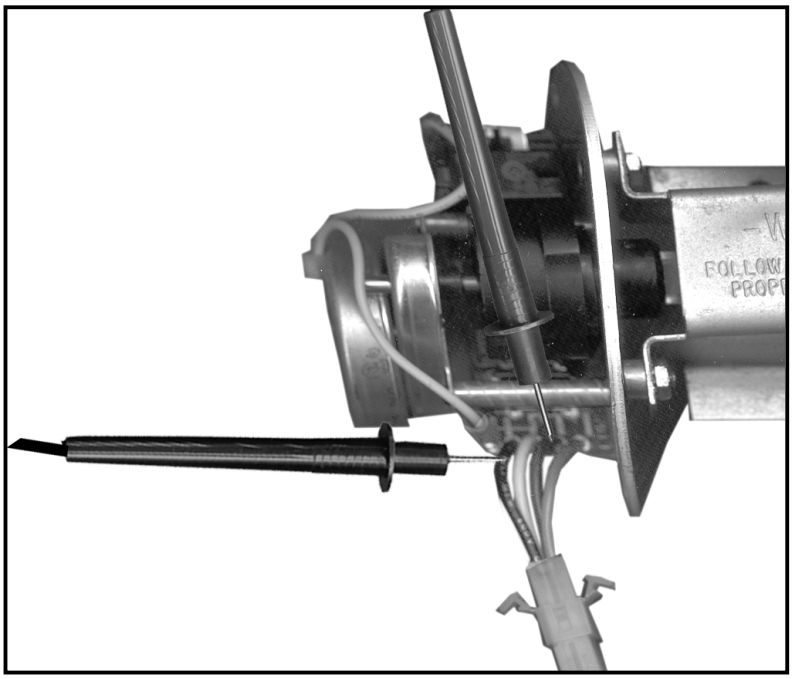
TROUBLESHOOTING THE EFFIKAL STYLE DAMPER

Condition:
Thermostat closed, damper

Wires are from left to right:
Black • Yellow • Brown • White



STEP A1	TEST BETWEEN BLACK (COMMON) AND BROWN ON THE DAMPER BOARD

IF	THEN
24VAC is present	This is correct
24VAC is not present	• See Steps 1 thru 4 Check the harness plugs connecting heater and damper for looseness or damage.

Condition:
Thermostat closed, damper in process of opening.

STEP A2	TEST FOR 24VAC BETWEEN BLACK AND ORANGE

IF	THEN
24VAC is present	This is correct
24VAC is not present	• See Step 7 • Check the harness plug connecting heater ----or damaged

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TROUBLESHOOTING THE EFFIKAL STYLE DAMPER (continued)

Condition:
Thermostat closed, damper is open fully

STEP A3	TEST FOR 24VAC BETWEEN BLACK AND YELLOW

IF	THEN
24VAC is present	This is correct – continue to Step 11
24VAC is not present	• See Step 9 • Check the harness plug connecting ---- • Check that cam on shaft rotates with shaft • Replace the damper board

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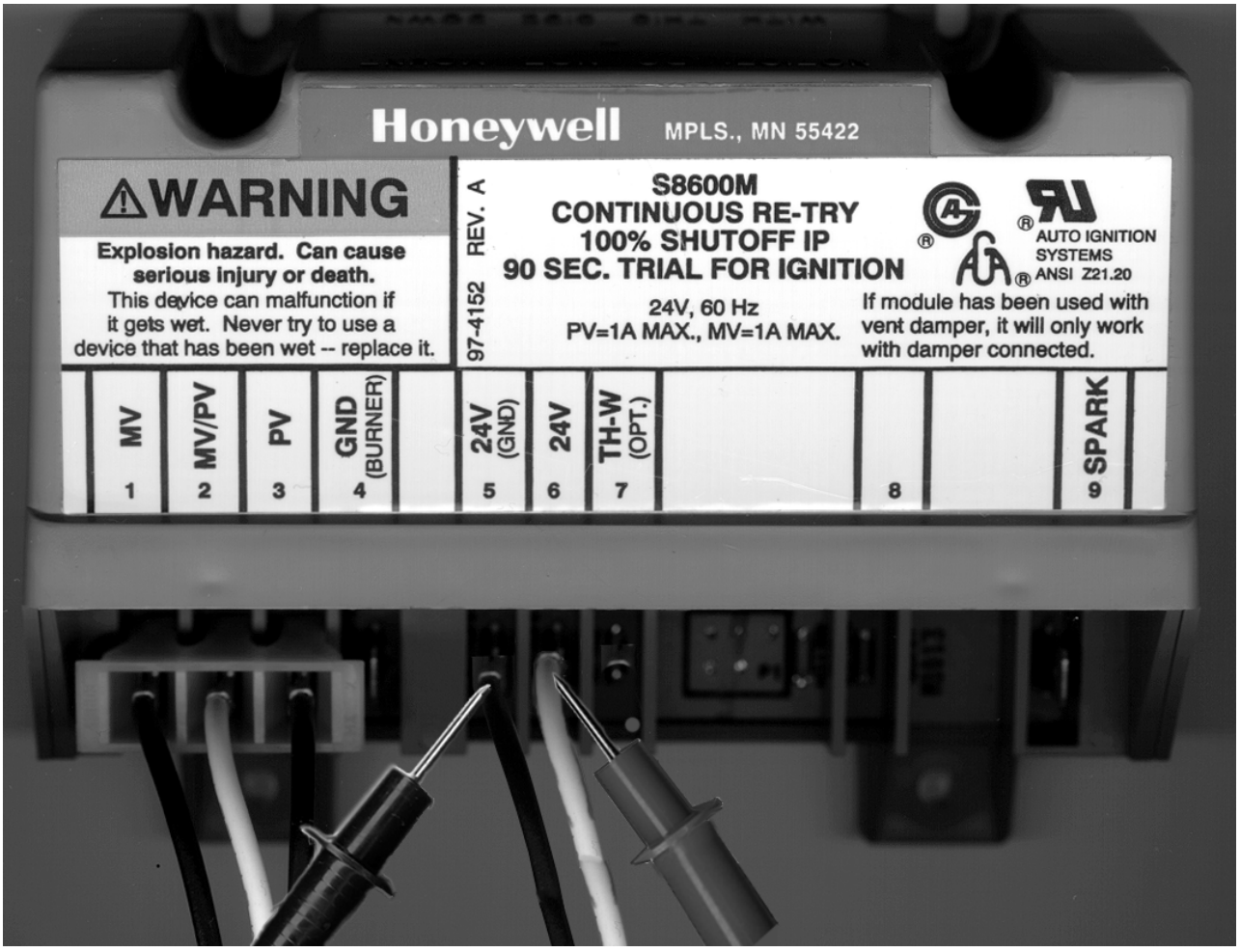
STEP 11 WIRE HARNESS TEST


Honeywell MPLS., MN 55422
WARNING
Explosion hazard. Can cause serious injury or death.
This device can malfunction if it gets wet. Never try to use a device that has been wet -- replace it.
97-4152 REV. A
S8600M
CONTINUOUS RE-TRY
100% SHUTOFF IP
90 SEC. TRIAL FOR IGNITION
24V, 60 Hz
PV=1A MAX., MV=1A MAX.
AUTO IGNITION SYSTEMS ANSI Z21.20
If module has been used with vent damper, it will only work with damper connected.
MV 1
MV/PV 2
PV 3
GND (BURNER) 4
24V (GND) 5
24V 6
TH-W (OPT.) 7
8
SPARK 9

STEP 11. WIRE HARNESS TEST. Test for 24 VAC between terminal 24V on the IID module, and 24V (GND).

IF	THEN
24 VAC is not present:	• Check the wiring harness.
24 VAC is present:	• Go to step 12.

Note: This test may be easier to conduct by removing the red wire from the IID terminal. Test for 24 VAC between the red wire and ground. Reconnect the red wire to the 24V terminal after the test.

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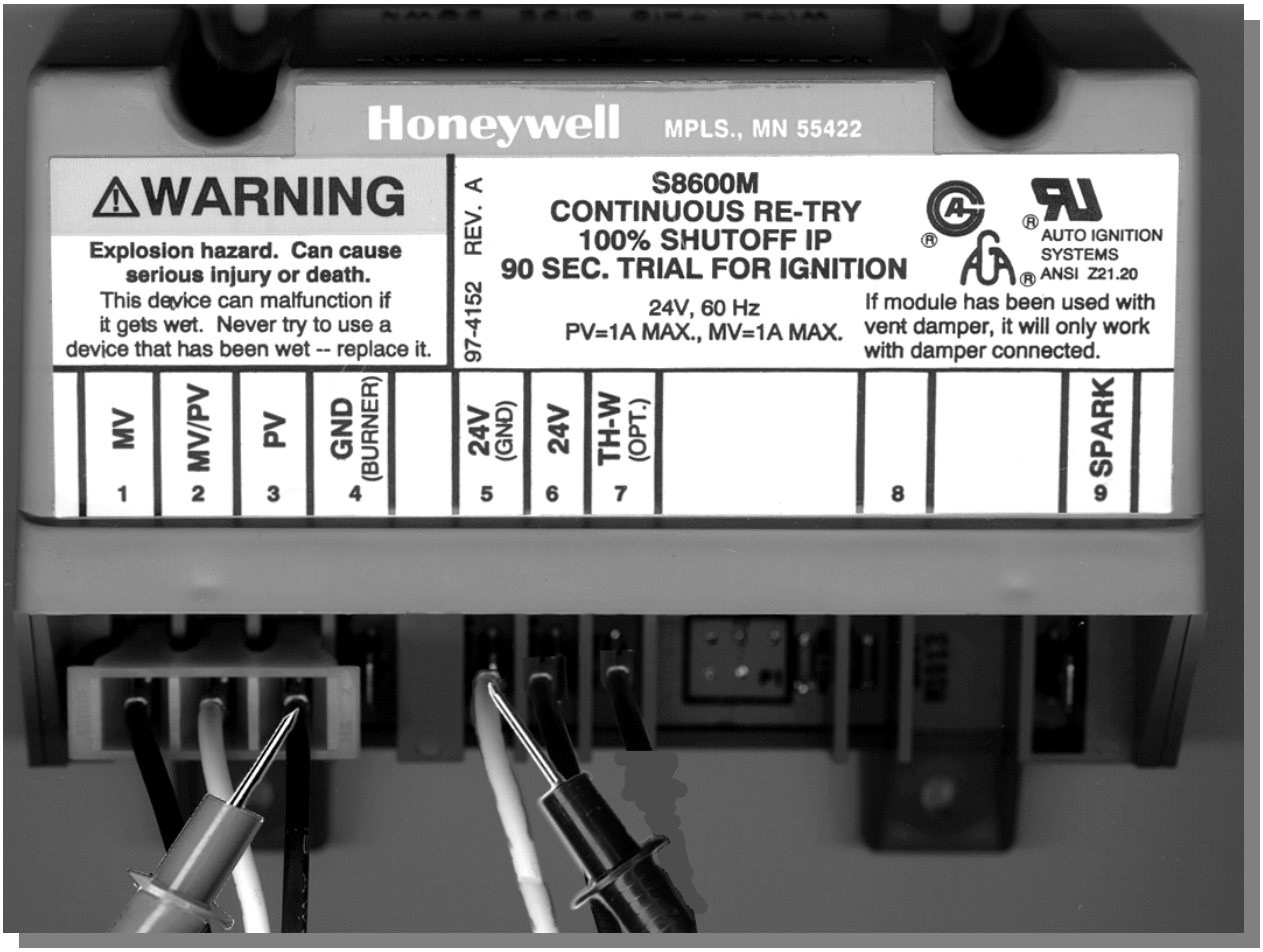
STEP 12 IID MODULE TEST


Honeywell MPLS., MN 55422
WARNING
Explosion hazard. Can cause serious injury or death.
This device can malfunction if it gets wet. Never try to use a device that has been wet -- replace it.
REV. A
97-4152
S8600M
CONTINUOUS RE-TRY
100% SHUTOFF IP
90 SEC. TRIAL FOR IGNITION
24V, 60 Hz
PV=1A MAX., MV=1A MAX.
AUTO IGNITION SYSTEMS ANSI Z21.20
If module has been used with vent damper, it will only work with damper connected.
MV 1
MV/PV 2
PV 3
GND (BURNER) 4
24V (GND) 5
24V 6
TH-W (OPT.) 7
8
SPARK 9

STEP 12. IID MODULE TEST (Power to the Pilot Valve). Using a multimeter, test for 24 VAC between terminal PV and 24V (GND) on the IID during the 90 second trial for ignition.

IF	THEN
The meter does not read 24 VAC and the IID module is not between ignition trials:	• Replace the module.
The meter does read 24 VAC:	• Go to step 13

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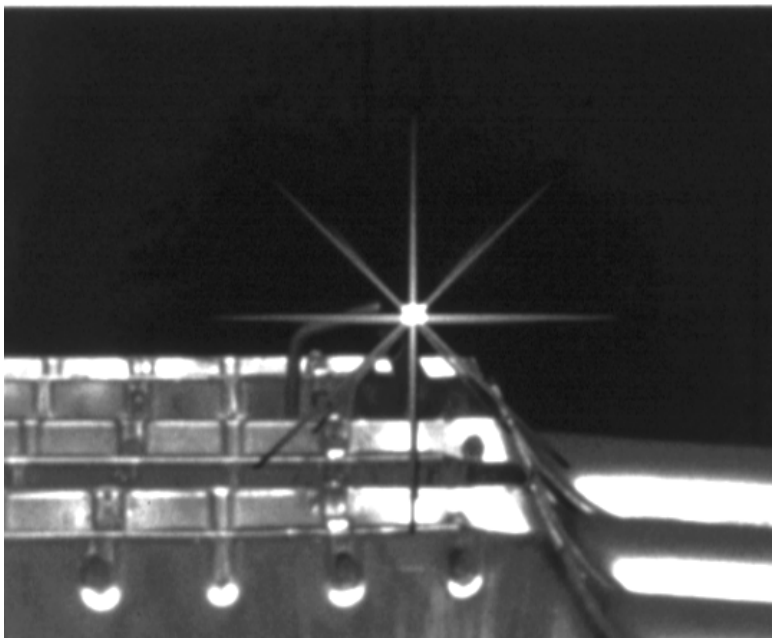
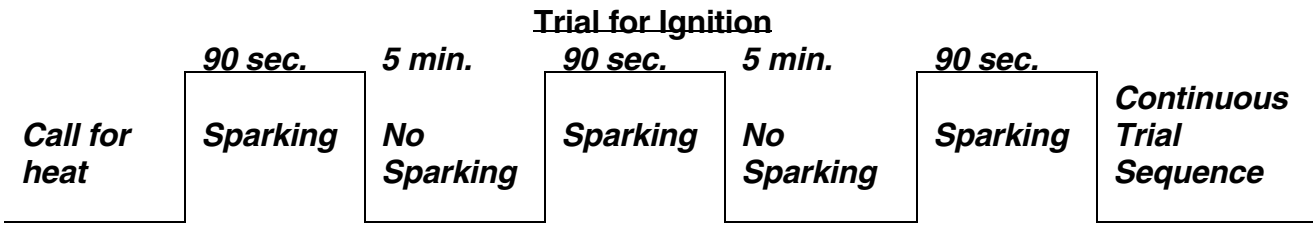
STEP 13 PILOT SPARK TEST



STEP 13. PILOT SPARK TEST. Visually check for spark at the pilot assembly.
Note: The pilot burner mounts on the left side of the main burner.

IF	THEN
The igniter is not sparking:	Check for: • A 7/64" spark gap • Spark cable continuity • Ground cable continuity
Sparking is present:	• Go to step 14.

Power To Module May Be Interrupted To Reset .



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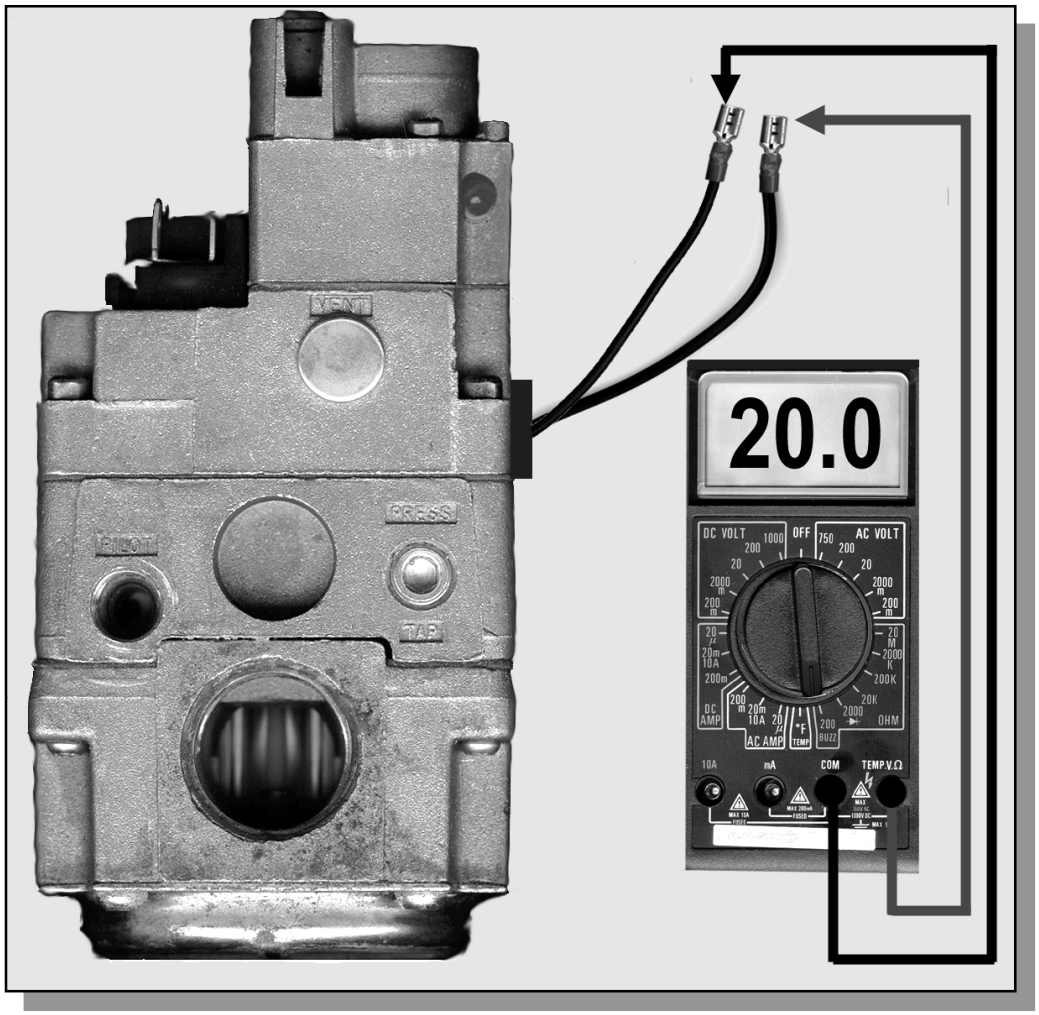
STEP 14A PILOT VALVE - OHM TEST



BTR 120 – 400 GAS VALVE

STEP 14A. PILOT VALVE - OHM TEST. If pilot assembly is sparking but no pilot flame is established, disconnect the pilot valve solenoid leads. Using a multimeter, (set to read ohms) test for 20* ohms resistance +/- 5 through the solenoid coil.

IF	THEN
The meter dose not read 20 ohms plus or minus 5:	• Replace gas valve
The meter does read 20 ohms plus or minus 5:	• Gas valve should work. Also check that pilot gas is present and pilot tube or orifice are not blocked

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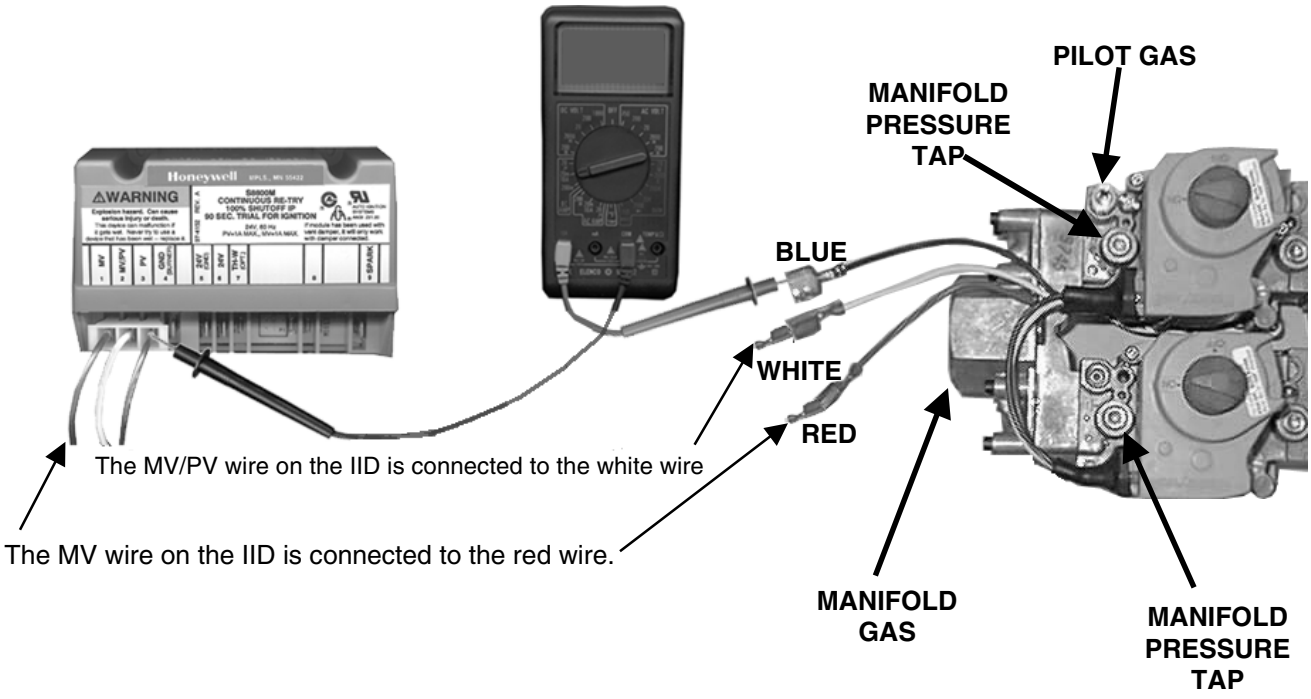
STEP 14B PILOT VALVE TEST – BTR 500 ONLY


PILOT GAS
MANIFOLD PRESSURE TAP
BLUE
WHITE
RED
The MV/PV wire on the IID is connected to the white wire
The MV wire on the IID is connected to the red wire.
MANIFOLD GAS
MANIFOLD PRESSURE TAP

STEP 14B. PILOT VALVE TEST – BTR 500 ONLY. Testing the two coils of the Honeywell VR8404P 5004 gas valve used on the model BTR 500 only. Because of built in diodes, it is difficult to test for ohms resistance through these coils. The following is a DC amperage check of the main and pilot coils.

Condition:

- Tank calls for heat
- PV terminal of module has 24 Vac
- No Pilot flame

Test Procedure:

- Turn off power to heater
- Meter set to test for DC amperage (on AOS meters, the black wire is in the "com" port, the red wire is in the "10A" port, the dial is set to 20M/10A in the DC AMP test area).
- Blue "PV" wire is disconnected from the ignition PV terminal.
- Install meter in series between gas valve and ignition module – 10A wire to blue gas valve lead, common wire to PV module terminal.
- Turn power on to heater, after module receives 24V

Test DC Amperage through Pilot coil of gas valve

IF	THEN
.75 to .85 DCA is not present:	• Replace the gas valve
.75 to .85 DCA is present	• Pilot should work if gas (not air) is present to pilot

Power off, reattach blue gas valve wire to PV terminal of module.

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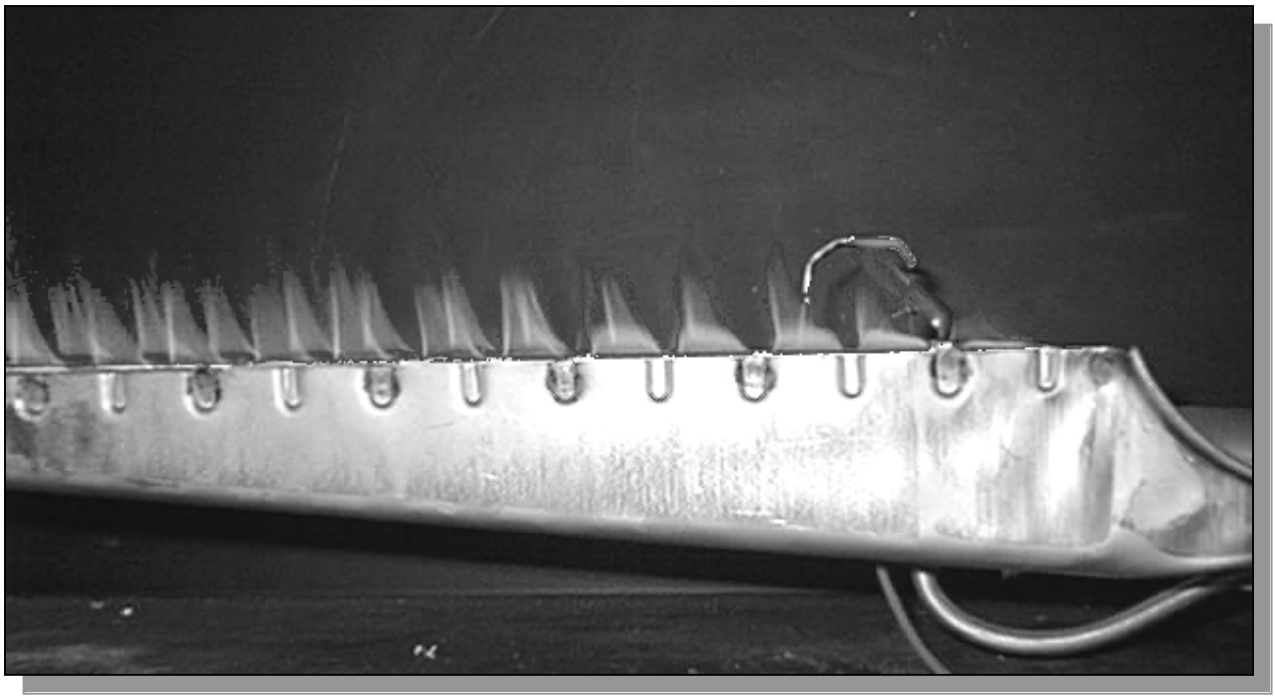
STEP 15 MAIN BURNER TEST



Note: BTR series 108 and 109 implemented a new main burner stamping process – burners appear the same as illustrated.

STEP 15. MAIN BURNER TEST. Visually check for main burner.

IF	THEN
The main burner ignites:	• Sequence is complete
The main burner does not ignite	• Go to step 16

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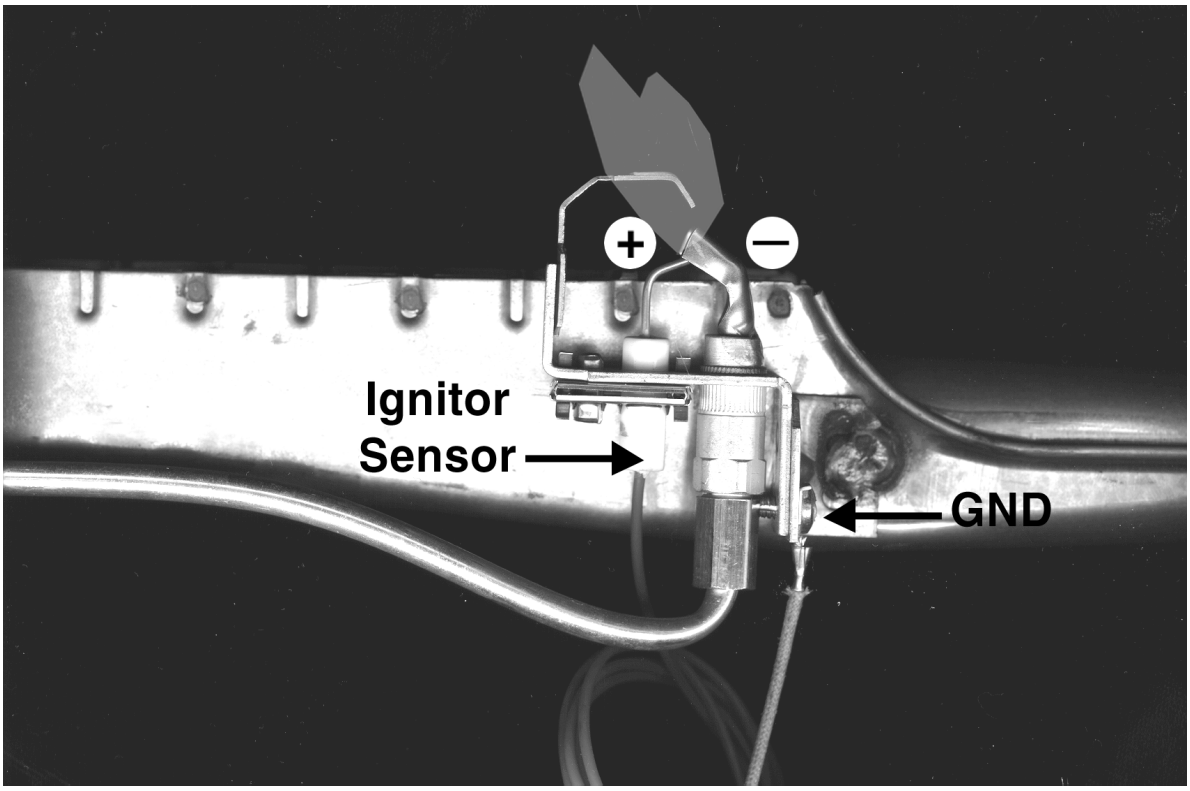
STEP 16 FLAME RECTIFICATION



STEP 16. FLAME RECTIFICATION

Note: Flame rectification means that an alternating current (AC) signal is changed to a direct current (DC) signal. The pilot flame is the 'switch' which connects the pilot hood to the igniter and ground. If the pilot hood and igniter sensor had the same surface area, the flame 'switch' would conduct an AC signal. Because the pilot surface is greater than the igniter surface, the signal becomes a DC current that the module can interpret. The pilot hood must be properly grounded and the pilot flame must remain in contact with both surfaces for the flame proving signal to remain constant.
If the signal is broken for just 8 tenths of a second, the heater will cycle off.
Sparking at the pilot will continue if an insufficient signal is received by the module.

Sparking at the pilot will stop almost immediately after the ignition module senses the pilot flame.

IF	THEN
Sparking continues after pilot is established:	• Check wire connections • Check flame contact between hood and lighter • Clean pilot burner surfaces • Replace pilot assembly
Sparking stops:	• Go to step 17.

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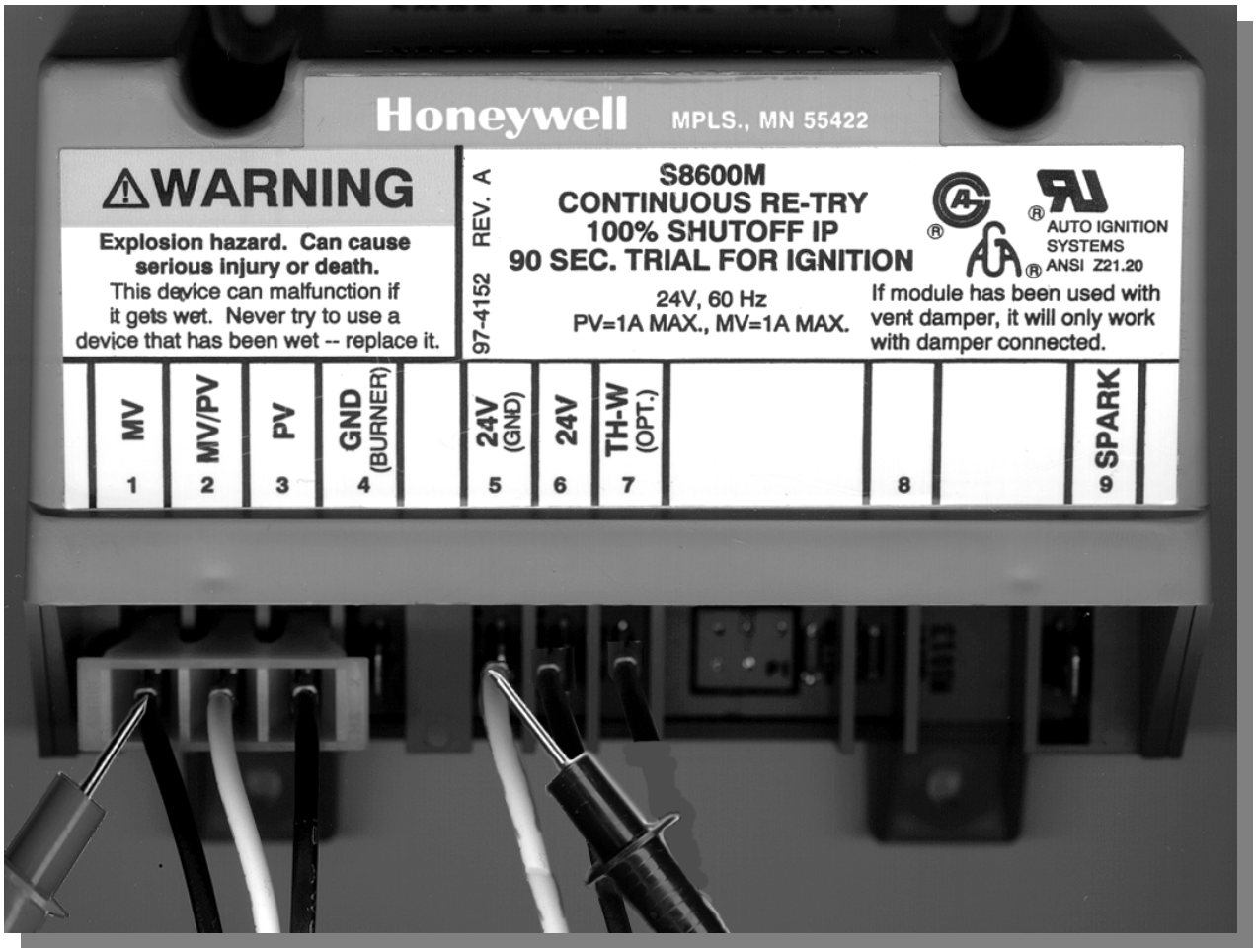
STEP 17 IID MODULE TEST


Honeywell MPLS., MN 55422
WARNING
Explosion hazard. Can cause serious injury or death.
This device can malfunction if it gets wet. Never try to use a device that has been wet -- replace it.
97-4152 REV. A
S8600M
CONTINUOUS RE-TRY
100% SHUTOFF IP
90 SEC. TRIAL FOR IGNITION
24V, 60 Hz
PV=1A MAX., MV=1A MAX.
AUTO IGNITION SYSTEMS ANSI Z21.20
If module has been used with vent damper, it will only work with damper connected.
MV 1
MV/PV 2
PV 3
GND (BURNER) 4
24V (GND) 5
24V 6
TH-W (OPT.) 7
8
SPARK 9

Pilot is lit - Sparking has stopped.

STEP 17. IID MODULE TEST (Power to the Main Valve). Using a multimeter, test for 24 VAC between terminal MV on the IID and 24V (GND).

IF	THEN
24 VAC is not present:	• Replace the IID module. Conduct Step 18 before applying power to replacement module.
24 VAC is present:	• Go to step 18.

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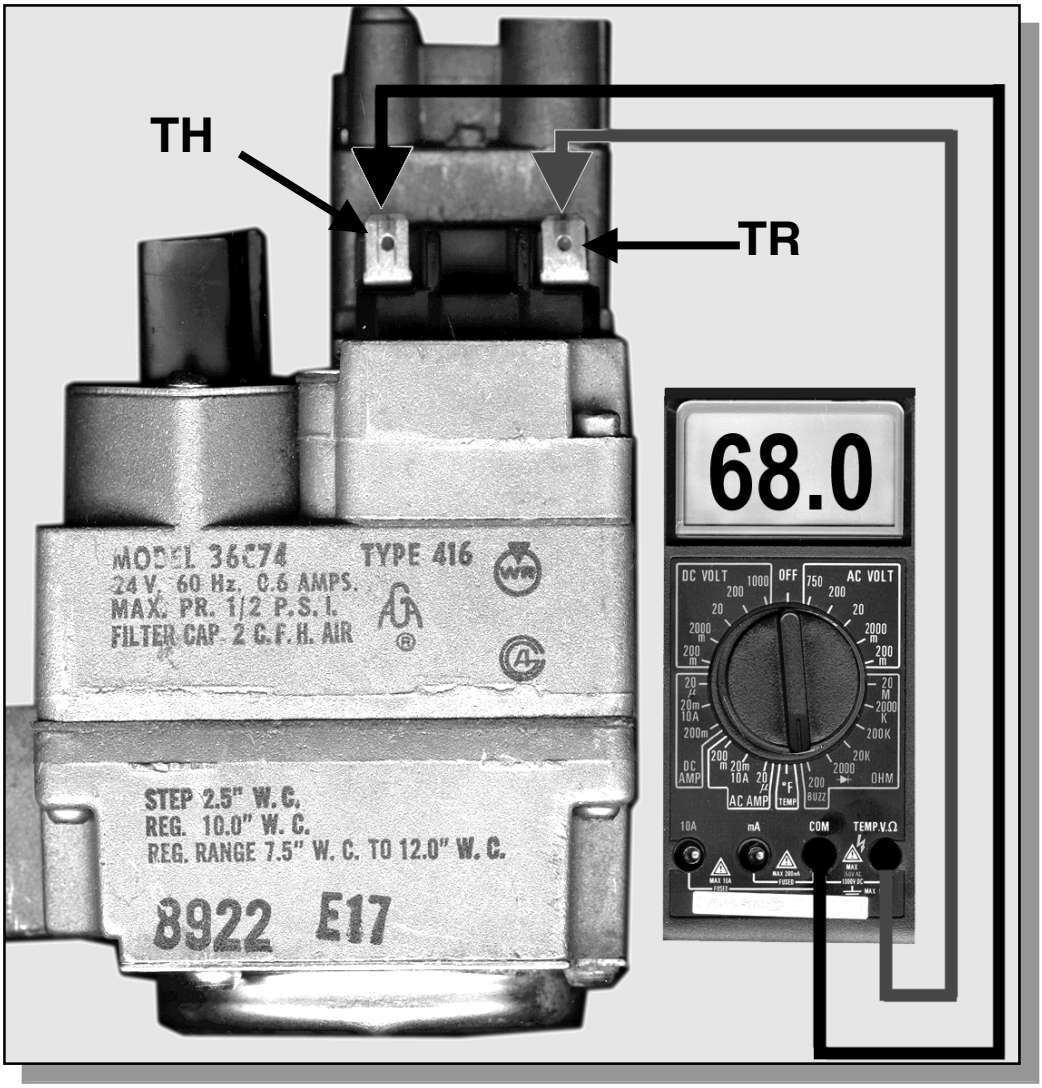
STEP 18A — MAIN GAS VALVE CHECK



BTR 120 – 400 GAS VALVE

STEP 18A. MAIN GAS VALVE CHECK. Disconnect wires from gas valve TH and TR terminals. Using a multimeter, test for 68 ohms plus or minus 5 between TH and TR on the main valve coil.

IF	THEN
The meter reads 'O' or infinity	• Replace the gas valve
The meter reads 68* ohms plus or minus 5	• The main burner will ignite

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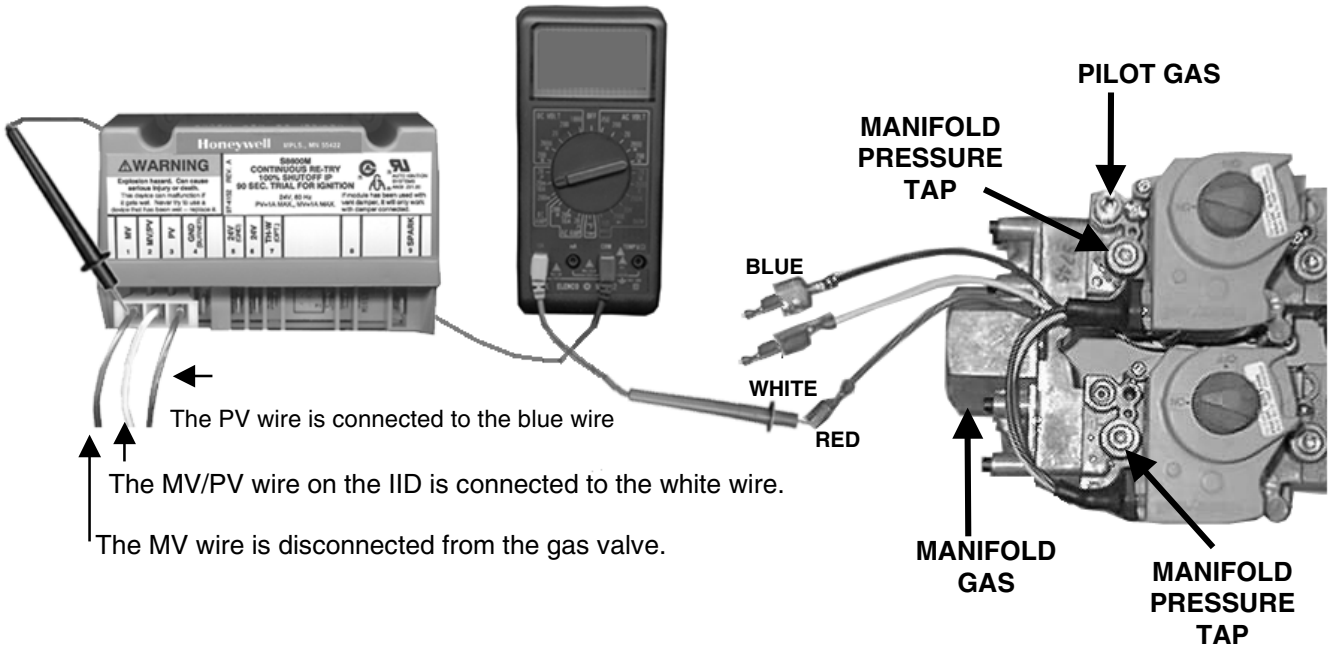
STEP 18B MAIN GAS VALVE COIL CHECK


PILOT GAS
MANIFOLD PRESSURE TAP
BLUE
WHITE
RED
The PV wire is connected to the blue wire
The MV/PV wire on the IID is connected to the white wire.
The MV wire is disconnected from the gas valve.
MANIFOLD GAS
MANIFOLD PRESSURE TAP

STEP 18B. MAIN GAS VALVE COIL CHECK – BTR 500 ONLY

Condition:

- Pilot lights
- Sparking stops
- No main burner ignition

Test Procedure:

- Power off
- Disconnect red, main valve wire from module MV terminal
- Meter set to test for DC amperage
- 10A wire to red gas valve wire, COM wire to MV terminal of ignition module
- Turn power on to heater
- After pilot lights and sparking stops

IF:	THEN:
.25 to .35 DC Amps is not present	• Replace the gas valve
.25 to .35DCA is present	• Main burner gas should ignite.

Be certain to correct you meter wire connections and setting before performing further tests.

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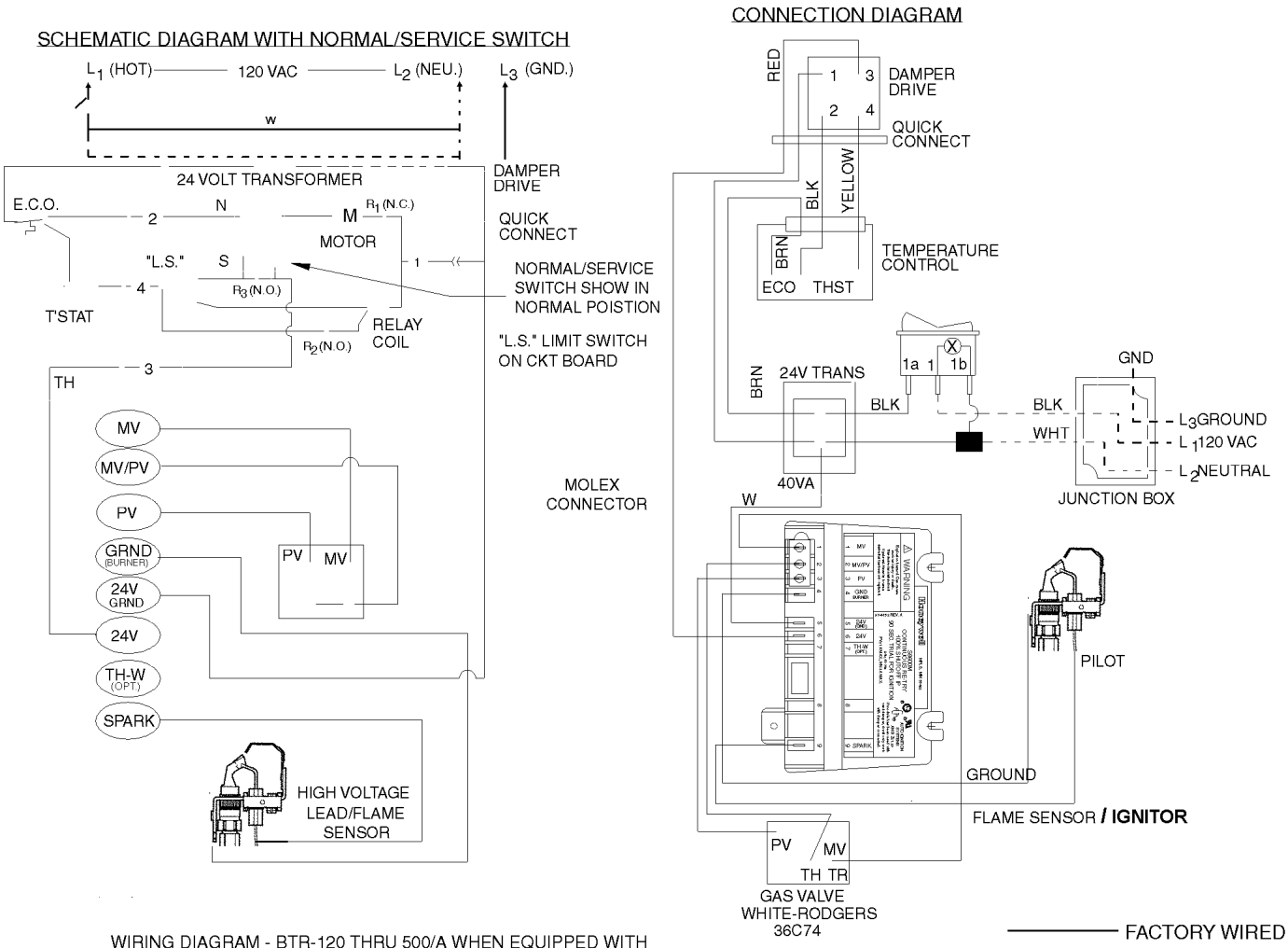
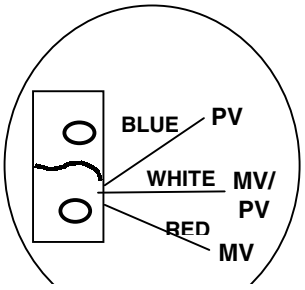
BTR WIRING DIAGRAM - NATURAL AND PROPANE GAS

Honeywell Ignition System (110 – 109 Series)



WIRING DIAGRAM - BTR-120 THRU 500/A WHEN EQUIPPED WITH A HONEYWELL IGNITION MODULE AND PILOT.
IF ANY OF THE ORIGINAL WIRE AS SUPPLIED MUST BE REPLACED, USE ONLY TYPE 105° C THERMOPLASTIC OR EQUIVALENT.
FLAME SENSOR IGNITION CABLE: MUST BE 250 C TYPE F

IF ANY OF THE ORIGINAL WIRE AS SUPPLIED MUST BE REPLACED, USE ONLY TYPE 105° C THERMOPLASTIC OR EQUIVALENT.



GAS VALVE FOR BTR-500/A ONLY

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GENERAL SERVICE CHART

CONDITION	CAUSE	SOLUTION
DAMPER OPENS NO POWER TO IID MODULE	. DAMPER NOT FULLY OPEN	.EFFIKAL – REPLACE DAMPER CONTROL ASSEMBLY . REPLACE DAMPER
	. DEFECTIVE PROTECTOR SWITCH	. REPLACE PC BOARD
PILOT LIGHTS, SPARKS CONTINUOUSLY	PILOT FLAME NOT PROVING	SEE FLAME RECTIFICATION - STEP 16
HEATER WILL NOT IGNITE	NOT PROVING PILOT FLAME EXISTANCE	INTERRUPT 120 VAC POWER . CHECK GROUND WIRE ATTACHMENT . CLEAN OR REPLACE PILOT ASSEMBLY
	PILOT GAS NOT COMPLETELY INTERRUPTED AT END OF HEATING CYCLE	. CHECK SUPPLY GAS PRESSURE . REPLACE GAS VALVE
WEEPING TEMPERATURE AND PRESSURE RELIEF VALVE	. THERMAL EXPANSION	ADD THERMAL EXPANSION TANK
	. FAULTY VALVE	REPLACE RELIEF VALVE
LARGE VOLUME WATER RELIEF FROM T&P VALVE	. EXCESSIVE WATER TEMPERATURE	. CHECK WIRING . REPLACE DUAL CONTROLLER
	. FAULTY RELIEF VALVE	REPLACE RELIEF VALVE
PREMATURE TANK LEAKAGE	CONDENSATION	. INCREASE STORED WATER TEMPERATURE AND CONFIRM PROPERLY SIZED APPLICATION
	CONTAMINATED AIR	. REMOVE CONTAMINANTS. . SUPPLY CLEAN COMBUSTION AIR.
	WATER HAMMER	. ADD WATER HAMMER ARRESTOR. . REDUCE WATER PRESSURE. . REMOVE UNNECESSARY CHECK VALVES.
	THERMAL EXPANSION	ADD THERMAL EXPANSION TANK.
	DEPLETED ANODES	SCHEDULE ANODE CHECKS - REPLACE AS NEEDED.
DAMPER WILL NOT OPEN	BINDING SHAFT	SUPPORT VENTING
	SHAFT SPRING WEAK/BROKEN	REPLACE DAMPER NON-EFFIKALS
	DAMPER MOTOR	REPLACE MOTOR EFFIKAL-REPLACE DAMPER CONTROL ASSEMBLY
NO SPARK AT PILOT - DAMPER FULLY OPEN	DAMPER ASSEMBLY	REPLACE PC BOARD - SEE STEP 10 Services Switch may bypass problem until replacement part is received. (EFFIKAL – REPLACE DAMPER CONTROL ASSEMBLY
	IID MODULE	REPLACE IID STEP 12
	SPARK CABLE	REPLACE CABLE STEP 13

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GENERAL QUESTIONS AND ANSWERS

Q. What changes caused series 106/107 and 108/109 to be implemented?

A. The 106 and 107 series units changed from the momentary push button to a slide switch. The 108 and 109 series implemented a new main burner construction process. The damper boards with service switch and new style main burners will automatically be replacement parts for previous series heaters if parts are ordered.

Q. What is unique about the Canadian – BTRC – models vs. U.S. BTR models?

A. The Canadian models have different dimensions to meet Canadian code requirements.

Q: How much electrical power is required for a BTR water heater?

A: The BTR models draw approximately .7 Amps at 120VAC.

Q: The units require "leg kits" to meet National Sanitation Foundation standards. What are the part numbers for these kits?

A: The BTR model heaters need AOS kit numbers:
BTR 120-400 (except BTR 197&198 series 100) = Part # 6570-0
BTR 197&198 Series 100 = Part # 6570-5
BTR 500 = Part # 6570-7

Q: When should BTRs be delimed?

Many variables affect the liming up process including:
water temperature - The amount of lime accumulation during the same period of time will be nearly 2 times greater if water is stored at 140 degrees F than at 120 degrees F. A 180 degree setting will build up lime about seven times as fast as a 140 degree F setting.
volume of water - The more gallons flowing through the BTR, the more rapid the accumulation.
hardness – The harder the water the faster lime build up occurs. 1 to 3.5 grains per gallon is "soft", 3.5 to 7 grains per gallon is "moderate", 7 to 10.5 grains per gallon is "hard" and 10.5 + grains per gallon is "very hard". (An aspirin is about 5 grains. One grain is equal to 17.1 parts per million.)

A: Deliming should be done when a slight rumbling or popping sound is detected when the main burners are on.

Q: What effect will lime build-up have on the BTR water heater?

A: One eighth inch of scale build-up may reduce efficiency as much as 22%; a 1/4 inch build-up, as much as 38%.

A: Less efficient heat transfer means more bottom head expansion/contraction stress and premature leakage.

A: Heavy build-up on the bottom head and bottom portion of the flue pipes leads to more heat transfer at the top of the flues. This can lead to stacking or erratic thermostat operation.

Q: Anode rods provide additional protection against corrosion. When should these be replaced?

A: When large gouges or pits appear in the anodes, replace them. It is recommended that these be inspected every 6 months.

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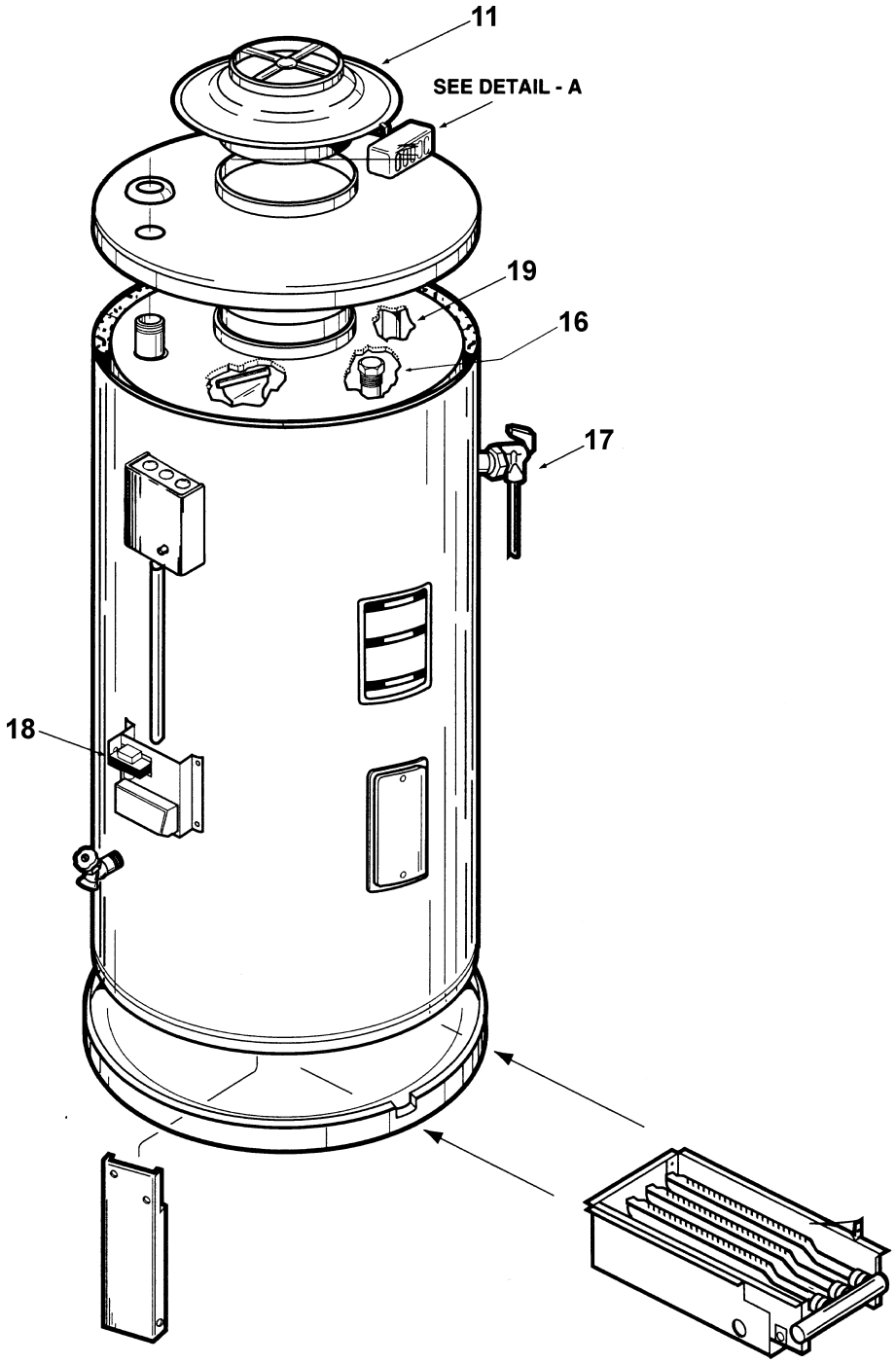
BTR MODELS 197 AND 198
Series 100-101



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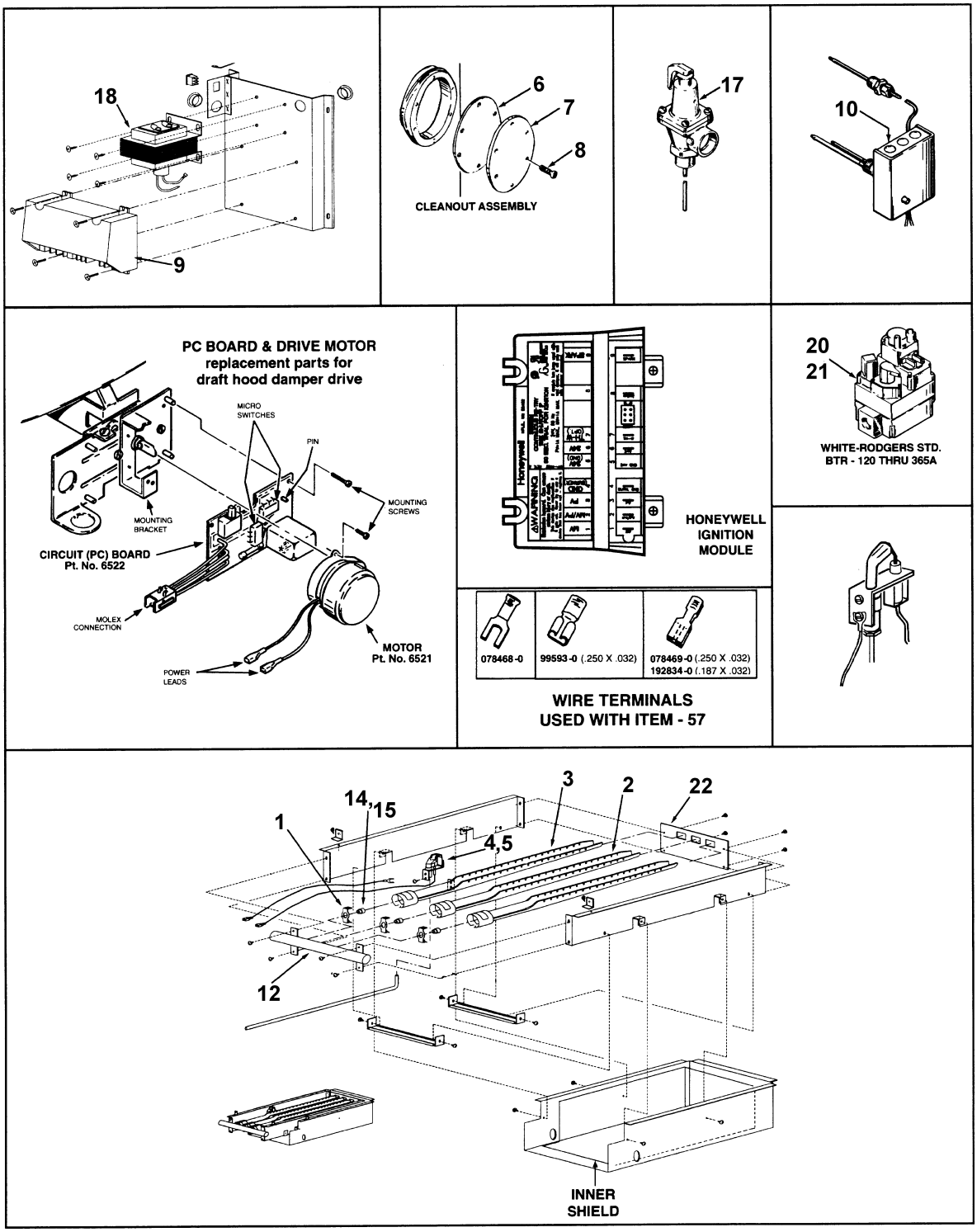
BTR MODELS 197 AND 198 (continued)
Series 100-101



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PARTS LIST for BTR Models 197 and 198 Series 100 & 101

Item	Parts Description	BTR 197	BTR 198
1	Bracket For Main Burner Orifice	098044(5)	098044(5)
2	Main Burner	192322	192322
3	Main Burner w/Pilot Bracket	193873-0	193873-0
4	Pilot Burner Natural	193314-0	193314-0
5	Pilot Burner Propane	193314-1	193314-1
6	Gasket	99036	99036
7	Pressure Plate	99037	99037
8	Screws, Self Tapping	69852	69852
9	Control, Ignition Module	193325	193325
10	Control, Dual w/ECO	192828	192828
11	Drafthood	192957-4	192957-4
12	Manifold	76244-2	76244-2
13	Instruction Manual	193927	193927
14	Main Burner Orifice Natural	76243-32	76243-32
15	Main Burner Orifice Propane	76243-49	76243-49
16	Anode Rod	43817-38 (4)	43817-42 (4)
17	T & P Relief Valve	99465-7	99465-7
18	Transformer	193444	193444
19	Inlet Tube	192626	192626
20	Gas Valve Natural	192827-2	192827-2
21	Gas Valve Propane	192827-3	192827-3
22	Off/On Switch	193243	193243

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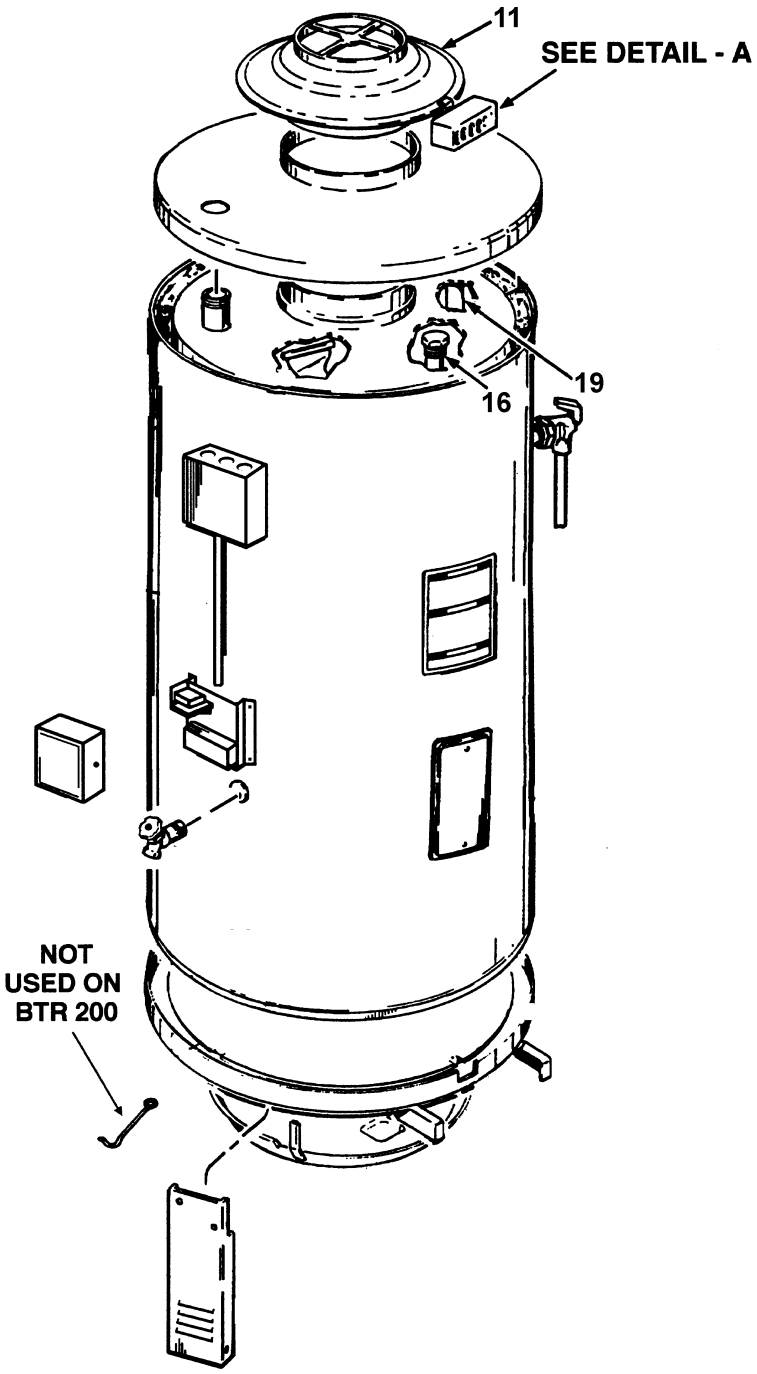
BTR MODELS 120 through 500
Series 104-105



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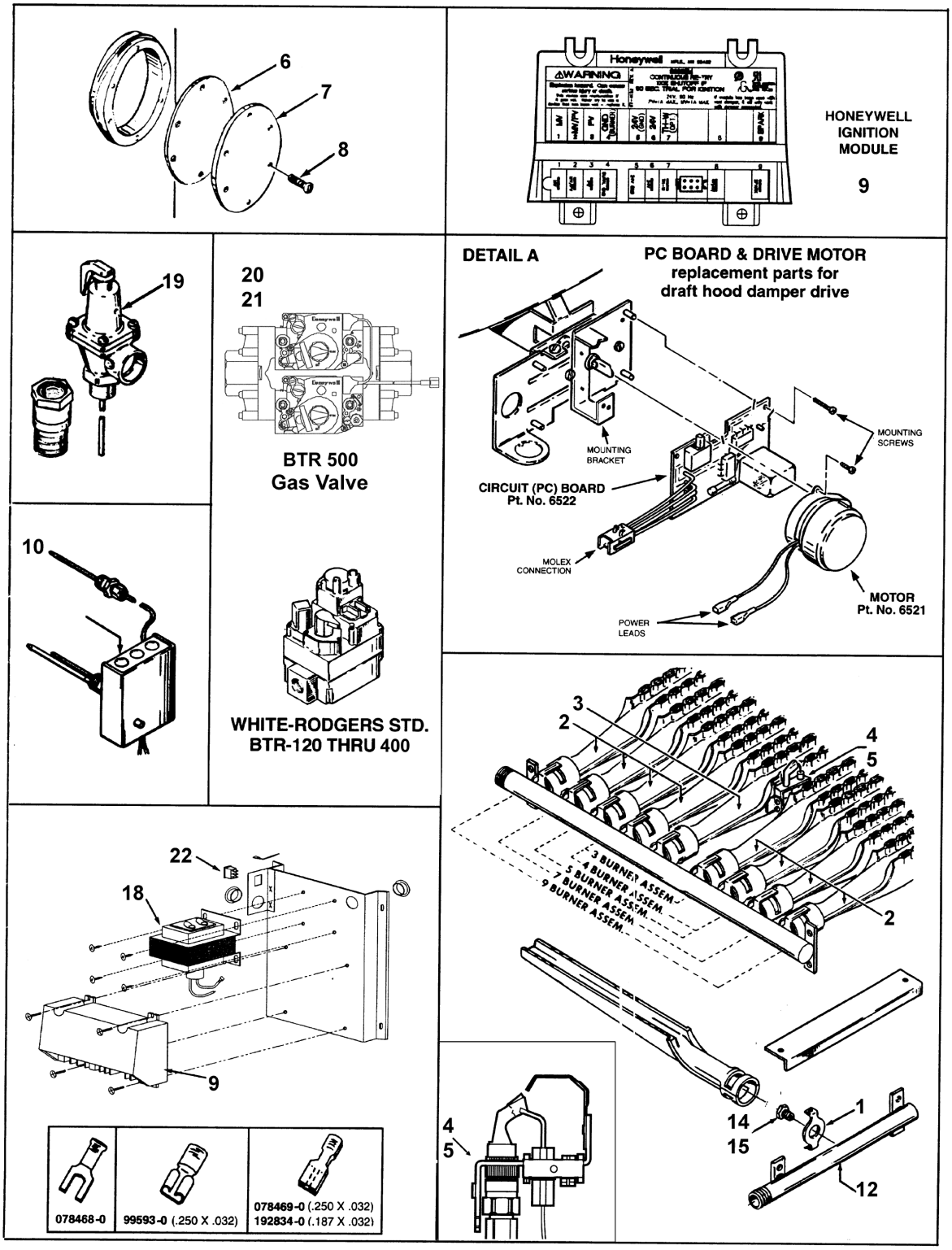
BTR MODELS 120 through 500 (continued)
Series 104-111



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PARTS LIST FOR BTR Models 120 Through 500(A)
Series 104 Through 109 Series

(Series 106/107 have a service switch on Circuit Board 6522; Series 108/109 have new main burner production method. Both parts will automatically be shipped on 104 thru 109 series heaters.)

Item	Parts Description	BTR-120	BTR-154	BTR-180	BTR-199	BTR-200	BTR-250
1	Main Burner, Orifice Bracket	98044(3)	98044(3)	98044(5)	98044(5)	98044(5)	98044(5)
2	Main Burner	192322	98047	192322	192322	192322	098047
3	Main Burner w/Pilot Bracket	193873-0	193873-1	193873-0	193873-0	193873-0	193873-0
4	Pilot Burner, Natural	193314-0	193314-0	193314-0	193314-0	R	193314-4
5	Pilot Burner, Propane	193314-1	193314-1	193314-1	193314-1	193314-1	193314-3
6	Gasket, Cleanout	99036	99036	99036	99036	99036	99036
7	Pressure Plate, Cleanout	99037	99037	99037	99037	99037	99037
8	Screw, Self tapping, Cleanout	69852	69852	69852	69852	69852	69852
9	Control, Ignition Module	193325	193325	193325	193325	193325	193325
10	Control, Dual w/eco	192828	192828	192828	192828	192828	192828
11	Drafthood	193597-0	193597-1	192957-0	192957-0	192957-0	193287
11	Drafthood 110, 111 Series						
12	Manifold	76244-0	76244-0	76244-2	76244-2	76244-2	76244-2
13	Instruction Manual, (not illustrated)	193927	193927	193927	193927	193927	193927
14	Main Burner Orifice, Natural	76243-32	76243-30	76243-35	76243-32	76243-32	76243-xx
15	Main Burner, Orifice, Propane	76243-49	76243-46	76243-51	76243-49	76243-48	76243-xx
16	Anode Rod	43817-38 (2)	43817-38 (2)	43817-38 (4)	43817-38 (4)	180618-42 (3)	180618-42 (4)
17	T & P Relief Valve	99465-7	99465-7	99465-7	99465-7	99465-7	192467
18	Transformer	193444	193444	193444	193444	193444	193444
19	Inlet Tube	193729	192626	193729	193729	192626	192626
20	Gas Valve, Natural	192827-2	192827-2	192827-2	192827-2	192827-2	192827-2
21	Gas Valve, LP	192827-3	192827-3	192827-3	192827-3	192827-3	192827-3
22	Off/On Switch	193243	193243	193243	193243	193243	193243

Item	Parts Description	BTR-251	BTR-275	BTR-305	BTR-365	BTR-400	BTR-500
1	Main Burner, Orifice Bracket	98044(7)	98044(5)	98044(7)	98044(9)	98044(9)	98044(9)
2	Main Burner	98047	98047	192322	192322	192322	192322
3	Main Burner w/Pilot Bracket	193873-0	193873-1	193873-0	193873-0	193873-0	193873-0
4	Pilot Burner, Natural	193314-4	193314-4	193314-4	193314-4	193314-4	193314-4
5	Pilot Burner, Propane	193314-3	193314-3	193314-3	193314-3	193314-3	193314-3
6	Gasket, Cleanout	99036	99036	99036	99036	99036	99036
7	Pressure Plate, Cleanout	99037	99037	99037	99037	99037	99037
8	Screw, Self tapping, Cleanout	69852	69852	69852	69852	69852	69852
9	Control, Ignition Module	193325	193325	193325	193325	193325	193325
10	Control, Dual w/eco	192828	192828	192828	192828	192828	192828
11	Drafthood	193287	193287	193287	193287	193287	193287
11	Drafthood 110, 111 Series						
12	Manifold	76244-3	76244-2	76244-3	76244-4	76244-4	76244-4
13	Instruction Manual, (not illustrated)	193927	193927	193927	193927	193927	193927
14	Main Burner Orifice, Natural	76243-xx	76243-xx	76243-37	76243-32	76243-31	76243-28
15	Main Burner, Orifice, Propane	76243-xx	76243-xx	76243-48	76243-49	76243-48	76243-44
16	Anode Rod	43817-38 (4)	180618-42 (3)	43817-38 (4)	180618-42(4)	180618-42 (3)	180618-42 (4)
17	T & P Relief Valve	192467	192467	192467	192467	192467	192467
18	Transformer	193444	193444	193444	193444	193444	193444
19	Inlet Tube	NA	192626	NA	192626	192626	192626
20	Gas Valve, Natural	192827-2	192827-2	192827-2	192827-2	192827-2	193366-0
21	Gas Valve, LP	192827-3	192827-3	192827-3	192827-3	192827-3	193366-1
22	Off/On Switch	193243	193243	193243	193243	193243	193243

∗ For complete parts list call 1-800-433-2545

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COMPONENT PART INFORMATION

	NAME	SPECIFICATIONS	AOS PART NUMBERS
DUAL CONTROLLER	THERMOSTAT	120-180° RANGE, ± 4°, 5° DIFFERENTIAL, LIQUID FILLED, ANTI-STACKING	AOS # 192828
	HIGH LIMIT (ECO)	OPENS - 205° FIXED, MANUAL RESET BELOW 185°	
GAS VALVE	NATURAL GAS	BTR 120-400;24VAC, 60hz, .6A,.7" to 3.5" W.C., STEP OPEN	AOS # 192827-2
		BTR 500; 24VAC, 60hz, Dual Gas Valve, STEP OPEN	AOS # 193366-0
	PROPANE GAS	BTR 120-400; 2.5 – 10" W.C. STEP OPEN	AOS # 192827-3
		BTR 500; 24VAC, 60hz, Dual Gas Valve, STEP OPEN	AOS # 193366-1
INTERMITENT IGNITION DEVICE CONTROL	NATURAL GAS AND PROPANE GAS	24 VAC, 50-60 HZ, .1A; .7 MICROAMP SIGNAL CONTINUOUS RETRIAL	AOS 193325
DAMPER	COMPLETE ASSEMBLY		SEE PARTS LIST
	MOTOR	24 VAC, 60 HZ, 120 RPM, 5 WATT	AOS #6521
	P.C. BOARD W/RELAY	Service Switch	AOS #6522
TRANSFORMER		120 V PRIMARY, 24 VAC SECONDARY, 40 VA, 50-60 HZ, CLASS 2 "B"	AOS #193444

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BTR SERVICE CHECKLIST

(This service checklist may be photo copied to assist with BTR service call.)

This checklist is intended to aid the Service Agent in determining that the A.O. Smith BTR Water Heater has been properly installed and is operating correctly. Because the circumstances of each installation may vary greatly, it is not intended to be an all-inclusive list of the problems that the Service Agent may encounter. Any item checked "no" on this list should be thoroughly investigated and corrective action taken, if required.

SERVICE AGENT _____ INSTALLATION DATE _____
MODEL NUMBER _____ SERVICE DATE _____
SERIAL NUMBER _____ LOCATION ADDRESS _____
_____
_____

GAS TYPE - CHECK ONE

NATURAL _____ PHONE( )_____-_____
PROPANE

I. Check Clearances (circle answer)
A. Are exterior clearances adequate? yes no
B. Are interior clearances adequate? yes no

Comments:

II. Check Makeup Air Requirements
A. Is the quantity of make-up air adequate per the National Fuel Gas Code? yes no

Comments:

B. Is the quality of make-up air adequate? yes no

Comments:

III. Gas Pressure (fill in blank)
A. Supply gas pressure _____ inches of w.c.
B. Manifold gas pressure (main burner) _____ inches of w.c.

Comments:

IV. Venting (check)
A. Properly sized per the National Fuel Gas Code? yes no
B. Does the installation have mechanically assisted venting? yes no

If so, is it operational? yes no

Comments:

V. WATER PIPING

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	Is the system properly sized?	yes	no
	Is the system properly installed?	yes	no
	Are there any water leaks?	yes	no
	Does the installation have a recirculating system?	yes	no
	If so, is it operational?	yes	no

VI. PROPER SEQUENCE OF OPERATION

	During standby does damper close on standby?	yes	no
	During standby is pilot flame off?	yes	no
	On a call for heat does thermostat close?	yes	no
	On a call for heat does damper open completely?	yes	no
	Does sparking begin at pilot?	yes	no
	Is pilot flame established?	yes	no
	If so, does sparking stop?	yes	no
	Does main burner ignite?	yes	no
	Does the thermostat satisfy?	yes	no
	Does damper close?	yes	no

Comments:

VII. SAFETY

A. Gas

	Does pilot flame prove before main burner ignites?	yes	no
	Does damper blade fully open before ignition sequence occurs?	yes	no
	Is burner cover plate in place?	yes	no
	Is burner floor shield in place?	yes	no
	Does IID lockout occur after 30 sec. trial for ignition? (Propane models only)	yes	no

B. Water Temperature

Is the thermostat adjusted to the lowest acceptable temperature?		yes	no
Does the installation have a mixing valve?		yes	no
	If so, is it operational?	yes	no
	What is the outlet temperature of the mixing valve? _____		

NOTE: *(To minimize the risk of scalding, the manufacturer recommends storing water at 120°F.)*

Is a properly rated temperature and pressure relief valve installed?	yes	no

C. Electrical

Is the 120 VAC electrical power supply properly wired?	yes	no
Are all the BTR control covers in place?	yes	no
Is the 120 VAC electrical power supply properly fused?	yes	no

D. Flammables

Are flammable materials located in the area of the water heater?	yes	no
Are flammable vapors located in the area of the water heater?	yes	no

Comments: _____

(This service checklist may be photo copied to assist with BTR service call.)

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COMMENTS

Author: Terry Mulder

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